



# Illinois Lake Michigan (nearshore) Mercury TMDL Report

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## List of Acronyms

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AOC	Area of Concern
BAF	Bioaccumulation Factor
BMP	Best Management Practice
BSAF	Biota-Sediment Accumulation Factor
CAA	Clean Air Act
CAIR	Clean Air Interstate Rule
CAMR	Clean Air Mercury Rule
CAWS	Chicago Area Waterway System
CWA	Clean Water Act
CSO	Combined Sewer Overflow
DL	Detection Level
FCMP	Fish Contaminant Monitoring Program
GI	Green Infrastructure
GIS	Geographic Information System
GLCFS	Great Lakes Coastal Forecasting System
GLI	Great Lakes Water Quality Initiative
GLNPO	Great Lakes National Program Office
GLRI	Great Lakes Restoration Initiative
HPV	Health Protection Value
IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
LA	Load Allocation
LaMP	Lakewide Management Plan
MATS	Mercury and Air Toxics Standards
MeHg	Methylmercury
MOS	Margin of Safety
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer System
MWRD	Metropolitan Water Reclamation District of Greater Chicago
NEI	National Emissions Inventory
NOAA	National Oceanic and Atmospheric Administration



NPDES	National Pollutant Discharge Elimination system
QAPP	Quality Assurance Project Plan
REMSAD	Regional Modeling System for Aerosols and Deposition
RF	Reduction Factor
TMDL	Total Maximum Daily Load
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WLA	Wasteload Allocation
WQS	Water Quality Standards



## Executive Summary

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Mercury is a naturally-occurring metal that is prevalent throughout the global environment and in Illinois. The well-known neurotoxic properties of mercury make it dangerous to both humans and wildlife, especially the young. Human exposure through the consumption of fish is the principal public health concern with mercury in the environment. Mercury emitted to the atmosphere can be transported long-distances from its source before being deposited to land and water. The widespread loading of mercury into the Great Lakes region is responsible for mercury-related fish consumption advisories in all of the eight Great Lakes states. This draft Total Maximum Daily Load (TMDL) report addresses mercury impairments in 56 waterbody segments located in the Illinois Lake Michigan nearshore. Appendix A lists specific waterbody segments covered by this TMDL.

The majority of mercury pollution in the study area waterbodies is a result of atmospheric deposition. This TMDL uses a target fish tissue concentration of 0.06 mg/kg, the concentration used by the Fish Contaminant Monitoring Program (FCMP) as the starting point for issuing a “one meal per week” advisory. This was used to set a reduction target for atmospheric mercury loading in order to achieve compliance with the fish consumption use.

Atmospheric mercury deposition in the study area comes from local, regional, national, and global sources that are both anthropogenic and natural in origin. Atmospheric mercury deposition originating from sources within and outside of Illinois was estimated for the baseline year of 2001<sup>1</sup> using a United States Environmental Protection Agency (USEPA) model. Based on the assumption that fish mercury concentrations will respond proportionally to reductions in atmospheric mercury loadings, a TMDL and a reduction goal were developed to meet the target fish tissue concentration of 0.06 mg/kg. Anthropogenic atmospheric sources of mercury from Illinois must be reduced by 89.29 percent from 2001 levels to meet this goal (Table ES-1). Reductions are necessary from mercury sources within Illinois and in other U.S. states, and from global sources. However, this TMDL only addresses reductions from Illinois sources. Progress on achieving this goal in Illinois will be tracked using air emissions from the year 2002 as a baseline, because a complete emissions inventory for the baseline year 2001 is not available.

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<sup>1</sup> The year 2001 was selected as a baseline because that was the year for which model results were available.

**Table ES-1. Summary of TMDL Components**

<b>TMDL Components</b>	<b>Results</b>
<b>Target Level and Reduction Factor</b>	
Target Fish Mercury Concentration (Fish Tissue Residue Value) <sup>2</sup>	0.06 mg/kg
Baseline Mercury Concentration for Largemouth Bass	0.28 mg/kg
Reduction Factor (RF)	78.57%
<b>Final TMDL</b>	
Loading Capacity (LC)	0.020 kg/day
Margin of Safety (MOS)	Implicit
Wasteload Allocation (WLA)	0.0003 kg/day
Load Allocation (LA)	0.020 kg/day
<b>Mercury Load Allocation for In-State and Out-of-State Deposition Sources</b>	
In-State Contribution to LA <sup>a</sup>	0.0036 kg/day
Out-of-State Contribution to LA <sup>b</sup>	0.0160 kg/day
<b>Necessary Reduction from Anthropogenic Emission Sources</b>	
	89.29%

Note: numbers may not sum exactly due to rounding

<sup>a</sup> Anthropogenic sources only

<sup>b</sup> Anthropogenic and natural sources

<sup>2</sup> . The 0.06-mg/kg fish tissue concentration is used by the Fish Contaminant Monitoring Program as the starting point for issuing a one meal/week advisory.

# 1

## Introduction

Section 303(d) of the Federal Clean Water Act and the USEPA's Water Quality Planning and Management Regulations (Title 40 of the Code of Federal Regulations [CFR] Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for all category 5<sup>3</sup> waterbodies that are not meeting Water Quality Standards (WQS) for a specific pollutant. These waterbodies are included on a state's 303(d) list. The TMDL process establishes the allowable loadings of a pollutant to a waterbody based on the relationship between pollution sources and water quality conditions of a waterbody. This allowable loading represents the maximum quantity of a pollutant that the waterbody can receive without exceeding WQS. The TMDL process provides states with the basis for establishing water quality-based controls, which provide the pollutant reductions necessary for a waterbody to attain WQS (USEPA, 1991).

Within the Illinois Lake Michigan Basin, the Illinois Environmental Protection Agency (IEPA) has identified 56 nearshore beach/shoreline, harbor, and open water segments that are impaired due to concentrations of mercury in fish tissue and the water column (IEPA, 2014). All of these waterbody segments are impaired for fish consumption use, and one segment (Waukegan Harbor North) is also impaired for aquatic life use. These impaired waters are included on Illinois' Clean Water Act (CWA) Section 303(d) list (IEPA, 2014).

The scope of this mercury TMDL covers the 56 nearshore beach/shoreline, harbor, and open water segments impaired due to mercury. It quantifies the pollutant load reductions needed to reduce mercury levels in fish tissue and the water column so that the waterbodies can meet water quality standards. This TMDL is based on a "Level One" approach, which allows for the data from all segments to be considered together as one area (Section 5). The resulting total load then applies to the entire study area (and not to each impaired waterbody segment).

The Illinois Lake Michigan Nearshore Mercury TMDL considers the following source categories for their contribution to overall mercury loads: hydrodynamic transport from the main lake; atmospheric loading; Municipal Separate Storm Sewer System (MS4) stormwater loading, flow reversals from the Chicago Area Waterway System (CAWS); and other point source discharges. The report covers each step of the TMDL process and is organized as follows:

- Section 2. Background
- Section 3. Applicable water quality standards and TMDL targets
- Section 4. Source assessment
- Section 5. Modeling approach
- Section 6. TMDL development
- Section 7. Implementation plan and monitoring recommendations
- Section 8. Public participation

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<sup>3</sup> Category 5 means available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed.



# 2

## Background

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This section provides background information for mercury TMDL development. It is divided into the following sections:

- Problem statement
- Study area and impaired waterbodies
- Data compilation and assessment of water quality

### 2.1 Problem Statement

Mercury is a naturally occurring element that is a silver-colored liquid at room temperature. Mercury has historically been valued for its ability to conduct electricity, measure pressure and temperature, and form alloys with almost all other metals.

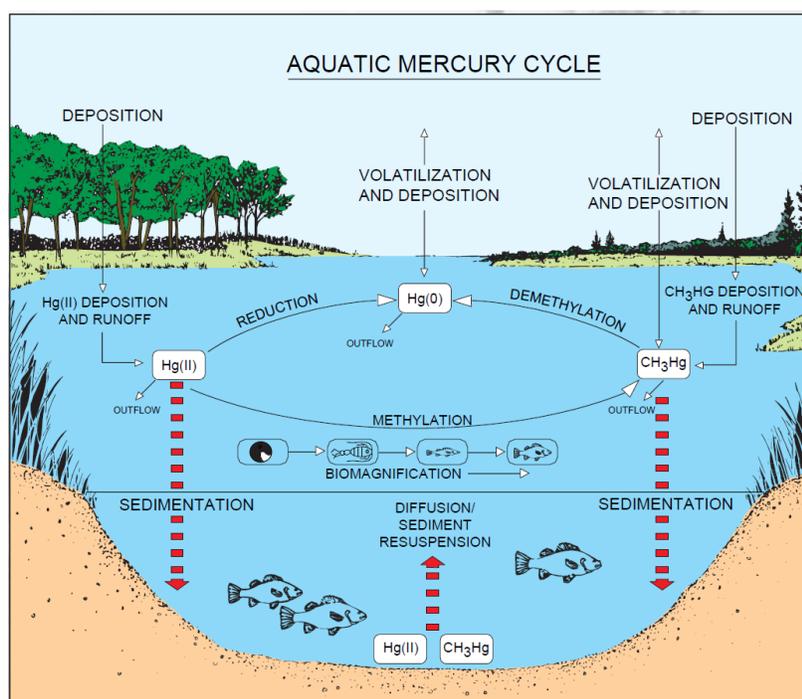
Because of these diverse properties, mercury has been used in a large number of household, commercial, medical, and industrial applications, including the following:

- Medical instruments and equipment, such as blood pressure gauges, thermometers, and x-ray machines
- Fluorescent lights
- Electrical switches and relays used in certain devices and equipment, such as lighting, thermostats, pumps, space heaters and computers
- Dental amalgam

Although mercury use in the United States has declined, the USEPA estimates that manufacturers use 500-600 metric tons of mercury annually as part of their production processes or to create products that rely on mercury's chemical and physical properties (USEPA, 2004).

On a global scale, numerous sources of both natural and anthropogenic origins release mercury to the atmosphere. Mercury releases from natural sources include the continuous and ubiquitous natural weathering of mercury-containing rocks, geothermal activity, or mercury emitted during episodic events such as volcanic eruptions (AMAP/UNEP, 2013). Anthropogenic sources refer to mercury released to the atmosphere from man-made sources, such as power plants, metals manufacturing facilities, caustic soda production plants, active or abandoned mines, ore processing facilities, incinerators for urban, medical and industrial wastes, cement plants, and chemicals production facilities. In addition, previously deposited mercury can be re-emitted from terrestrial and aquatic surfaces through natural processes including biomass burning and emissions from soil, inland waters, oceans, and vegetation. Once mercury enters the atmosphere, it becomes part of a global cycle of mercury among land, water, and the atmosphere. The atmosphere serves as the most important pathway for the worldwide dispersion and transport of mercury (Fitzgerald et al., 1998; Mason et al., 1994; Mason and Sheu, 2002). Airborne mercury returns to the terrestrial and aquatic environments via wet and dry deposition. Mercury undergoes complex biogeochemical cycling in terrestrial and aquatic environments.

Mercury exists in three forms: elemental mercury, inorganic mercury, and organic mercury. Under certain environmental conditions, inorganic mercury can be combined with carbon to form organic mercury compounds, of which methylmercury (MeHg) is the most abundant. The formation of MeHg is an important step in mercury cycling (Ullrich et al., 2001). Although all chemical forms of mercury are toxic, public health concerns focus on methylmercury. This is because MeHg can be bioaccumulated along the food web and reach high concentrations in aquatic organisms. Methylmercury is produced through the addition of a methyl group to  $Hg^{2+}$ , a process referred to as methylation (Figure 2-1). Methylation is performed primarily by sulfate-reducing bacteria (Compeau and Bartha, 1985; Regnell et al., 1996; Gilmour et al., 1998), which are found at zones of transition from oxic (i.e., containing oxygen) to anoxic (i.e., not containing oxygen) conditions in the water column or sediment (Bloom et al., 1999; Gilmour et al., 1998; Devereux et al., 1996; Slotton et al., 1995; Watras et al., 1994; Choi and Bartha, 1993). Net methylmercury production (i.e., methylmercury production in excess of degradation) is the most important environmental process that leads to food web accumulation.

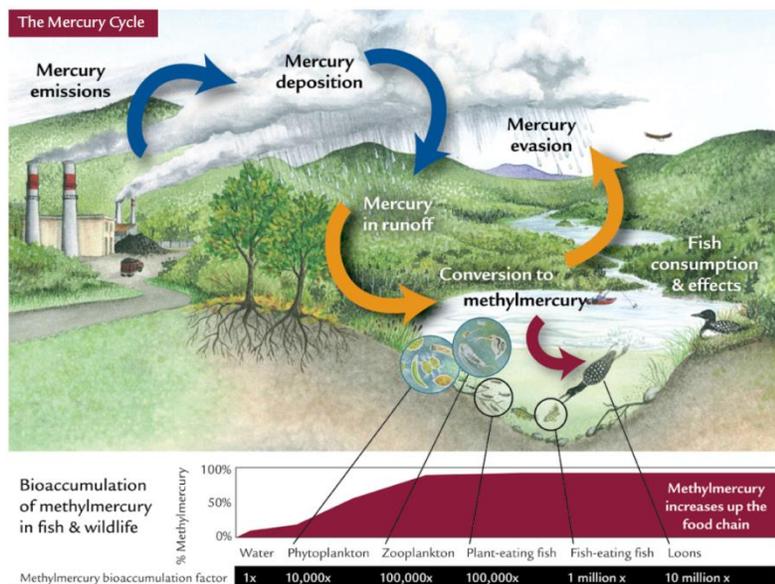


These pathways are very complex. The various forms of mercury can be converted from one to the next; most important is the conversion to methylmercury, the most toxic form. Ultimately, mercury ends up in the sediments, fish and wildlife, or returns to the atmosphere by volatilization. (Source: USGS, 2012)

**Figure 2-1. Mercury Cycling Pathways in Aquatic Environments**

The strong reactivity of methylmercury with sulfhydryl groups of proteins in the body is responsible for its high degree of bioaccumulation in fish and other types of organisms (Beckvar et al., 1996). Phytoplankton can concentrate dissolved methylmercury in the water column approximately 100,000 times greater than water column concentrations, making this a critical step in the bioaccumulation process (Watras et al., 1994). After this initial step, methylmercury concentrations increase approximately three-fold with each additional step in the food chain (Watras et al., 1994), in a process known as biomagnification (Figure 2-2). In this process, consumers retain and further concentrate much of the methylmercury of their prey, and subsequently pass the higher levels of mercury on to the next trophic level. Species at high trophic

levels in the aquatic food web, such as predatory fish, attain methylmercury concentrations that can be up to a million times higher than the concentration in water.



**Figure 2-2. A Simplified Mercury Cycle Showing How Mercury Enters and Cycles through Ecosystems, Biomagnifies up the Foodweb and Bioaccumulates in Fish and Wildlife (Source: Evers et al., 2011)**

One of the major routes of human exposure to methylmercury is through the consumption of contaminated fish (Clarkson and Magos, 2006). Globally, the ingestion of fish contaminated with MeHg is the most common means of mercury poisoning (BRI and IPEN, 2013). Even low levels of prenatal MeHg exposure may cause early childhood neurocognitive effects (Karagas et al., 2012). When ingested, methylmercury in fish tissue is almost completely absorbed from the gastrointestinal tract. Once absorbed, methylmercury is distributed throughout the body and is concentrated in the brain, liver, kidneys, peripheral nerves, and bone marrow. For pregnant women, methylmercury also concentrates in the placenta, fetus, and particularly the fetal brain (Berlin et al., 2007). Methylmercury is a known neurotoxicant. The ability of methylmercury to cross the placenta as well as the blood-brain barrier allows methylmercury to accumulate in the brain and fetus, which are known to be especially sensitive to the toxic effects of this chemical (Klasing and Brodberg, 2008). In the United States alone, it is estimated that over 300,000 newborns each year may be at risk of adverse neurodevelopmental effects due to *in utero* exposure to MeHg (Mahaffey et al., 2004).

Fish, birds, and other animals are also sensitive to mercury in the environment. Consumption of fish by other animals is the primary mechanism for methylmercury exposure; therefore, aquatic species are particularly vulnerable to mercury contamination. Toxic effects have been documented in animals who consume fish with a mercury concentration starting at 0.3 to 0.7  $\mu\text{g/g}$  wet weight in the whole body of fish (Wiener et al., 2007). Depew et al. (2012) proposed a threshold of 0.1  $\mu\text{g/g}$  wet weight methylmercury in prey fish, for adverse behavioral impacts in adult loons. They also proposed benchmarks of 0.18 and 0.4  $\mu\text{g/g}$  wet weight in prey fish for significant reproductive impairment and for reproductive failure, respectively, in wild adult loons.

### 2.1.1 Recent Mercury Trends

Recent estimates of annual global mercury emissions corresponding to the year 2010 are in the range of 6,000–9,000 MT/yr (Pirrone et al., 2010; AMAP/UNEP, 2013; Holmes et al., 2010). Approximately

2,000 MT/yr of mercury emissions to the air are from anthropogenic sources. Natural emission (geogenic origin) contributes to about 80–600 MT/yr to annual global emissions. Re-emission accounts for roughly 4,000–6,000 MT/yr of the global annual mercury emissions to air. Re-emissions are the result of environmental accumulation of mercury from legacy releases to air, land, and water. Although original sources of re-emitted mercury cannot be determined, the bulk of re-emitted mercury is from historical anthropogenic sources. Mercury emissions sources in developed countries such as the United States and Europe are better known than those in developing countries. In North America and Europe, the highest contribution to mercury emissions originates from fossil fuel combustion (Pirrone et al., 2010). China contributes one-third of the global anthropogenic total. A large fraction of the anthropogenic mercury emission from China is attributed to coal combustion. Asia contributes roughly 50 percent of the global total anthropogenic emission (UNEP, 2013). Mercury emissions in the United States and Europe have declined over the past several decades due to the implementation of pollution control technologies, while emissions from Asia are increasing largely due to expanding energy generation from coal-fired power plants. Global anthropogenic mercury emissions are expected to remain stable at current levels of around 2,000 MT/yr or increase only slightly, with decreases in North America and Europe being offset by increases in Asia (Pirrone et al., 2010; Wilson et al., 2010; UNEP, 2013).

Mercury emissions in the United States have declined from 250 tons in 1990 to 100 tons in 2005 (Schmeltz et al., 2011). Approximately 60 tons of mercury were emitted to the air, based on the 2008 emissions inventory (AMAP/UNEP, 2013). Similarly, mercury emission in the Great Lakes region declined from approximately 70 tons in the 1990 to 35 tons in 2005 (Evers et al., 2011). Most of the declines during this period were attributed to decreases in mercury emissions from medical and municipal waste incinerators. Currently, coal-fired power plants are the single largest source of mercury emissions nationwide and in the Great Lakes region (Evers et al., 2011; Schmeltz et al., 2011).

Recently, Risch et al. (2012) reported on mercury wet deposition patterns across 37 sites in the Great Lakes region from 2002 to 2008. During this period, annual mercury wet deposition was largely unchanged in the Great Lakes region. Local trends of decreasing mercury concentrations in precipitation and increasing precipitation depths were observed at several sites. Overall, it was suggested that any observed declines in mercury concentration were offset by increases in precipitation amount, and as such the total wet deposition amount remained largely unchanged. In general, wet deposition of mercury was highest in Indiana, Ohio, Illinois, eastern and northwestern Pennsylvania, southern Michigan, and southeastern Wisconsin, overlapping with areas with relatively high emissions of mercury from anthropogenic sources. The highest mean annual mercury wet deposition was reported for much of Indiana and Southern Illinois (12 – 14  $\mu\text{g}/\text{m}^2/\text{yr}$ ). The lowest was in northern Minnesota, eastern Ontario, Quebec, and parts of New York (4 – 6  $\mu\text{g}/\text{m}^2/\text{yr}$ ).

Evers et al. (2011) evaluated long-term mercury trends in fish in the Great Lakes region. Mercury concentrations in walleye and largemouth bass were evaluated from across multiple sites in the Great Lakes and inland water bodies in the Great Lakes states. Results from this study have shown an overall decline in fish mercury concentration in the Great Lakes region from 1967 to 2009. Much of this decrease has been attributed to reductions in regional mercury emissions. There have been several studies on the long-term (since 1970's) temporal trends in mercury levels in whole-body lake trout and walleye collected from the Great Lakes (Bhavsar et al., 2010; Environment Canada and the USEPA, 2014). These studies found that generally, in all five Great Lakes, fish mercury concentrations declined approximately until the mid-1990s, after which the declines ceased and mercury concentrations started to increase.

## 2.2 Study Area and Impaired Waterbodies

The project study area, shown in Figure 2-3, includes one nearshore open water segment, 51 beach/shoreline segments, and four harbors that are identified by the IEPA (IEPA, 2014) as being

impaired due to mercury. All 56 impaired waters are in Lake and Cook Counties, Illinois. All segments are classified as *Not Supporting* for fish consumption use, and Waukegan Harbor North is also classified as *Not Supporting* for aquatic life use. Appendix A contains a full listing of the impaired segments and causes. How these segments are identified is further defined in Section 3 of the TMDL.

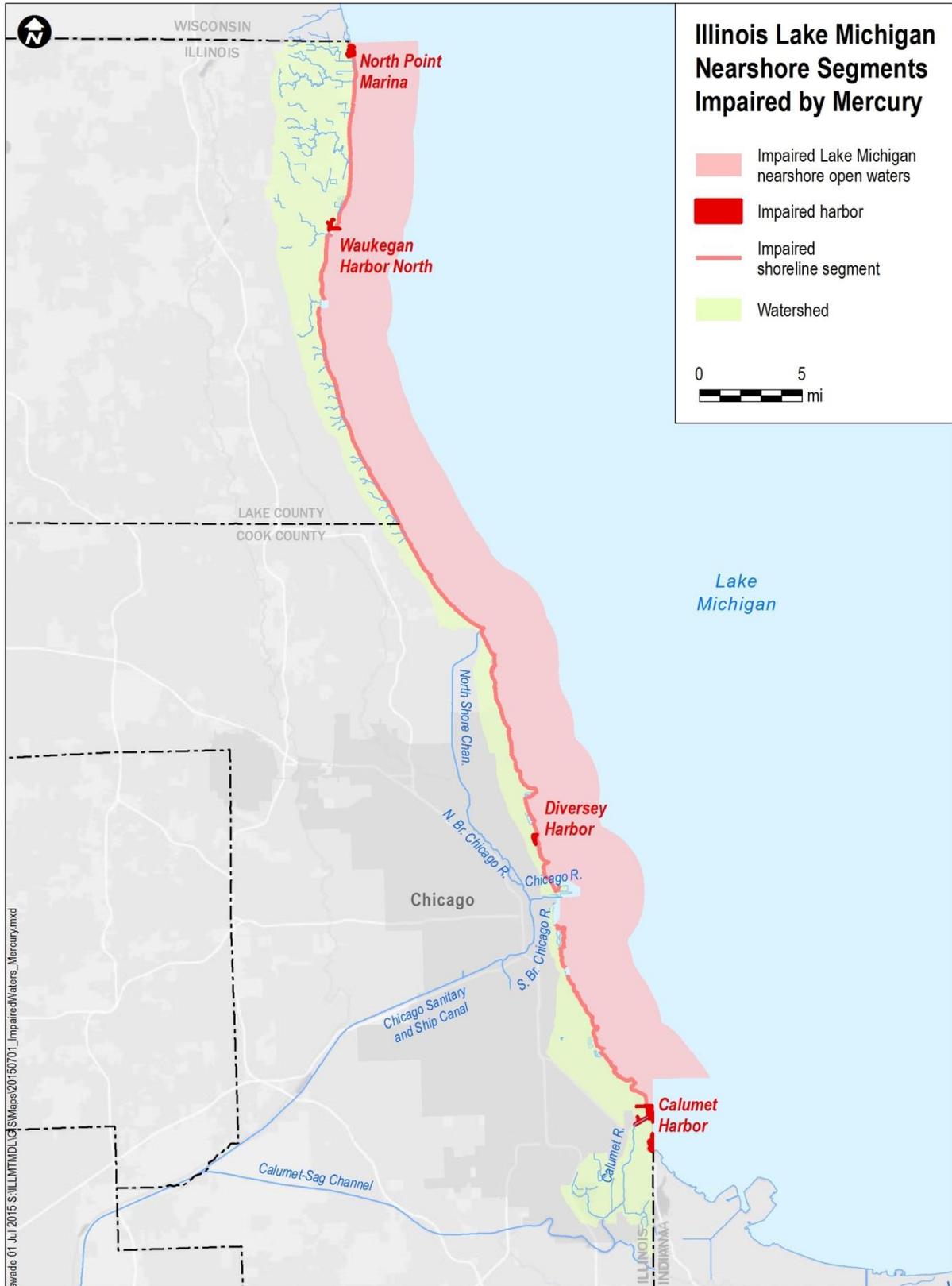


Figure 2-3. Project Study Area and Impaired Segments

### 2.2.1 Watershed Description

The study area watershed is long and narrow and encompasses roughly 100 square miles within Lake and Cook Counties, Illinois, that drain to Lake Michigan. The study area watershed is highly developed, and land use is roughly distributed as 73 percent residential, 4 percent industrial, 4 percent commercial, and 19 percent open space. The watershed includes portions of the following municipalities: Wilmette, Winnetka, Kenilworth, Winthrop Harbor, Chicago, Burnham, Highland Park, Lake Bluff, Beach Park, Highwood, Waukegan, North Chicago, Zion, Evanston, Glencoe and Lake Forest. All of the listed municipalities except Burnham have MS4 permits to discharge to Lake Michigan. The MS4 permits for these municipalities, together with the MS4 permits for the Cook County Highway Department, Lake County, Shields Township, and Waukegan Township, cover roughly 100 percent of this drainage. Although a number of permitted point sources are located in the watershed, none were identified that have the potential to discharge mercury to the impaired waters.

The waterbodies within the watershed are generally small streams and ravines that carry intermittent stormwater and surface drainage to Lake Michigan. Within Lake County, the watershed boundary extends inland farther than it does in Cook County, narrowing near the south end of Lake County due to the diversion of flows into the Chicago Area Waterway System (CAWS). The CAWS is heavily altered from its natural state, including a diversion of the Chicago River (in 1900), and the Little and Grand Calumet River (in 1922) away from Lake Michigan via the CAWS. The CAWS is a major component of the study area, comprising both manmade and natural waterways. In addition to navigation, these waterways convey a variety of point-source and precipitation-related flows, including water reclamation plant effluents, combined sewer overflows (CSOs), and stormwater runoff. While the direction of flow in the CAWS is typically toward the Des Plaines River watershed and away from the study area waterbodies, extreme wet weather conditions can create storm flows large enough to cause flow reversals in the CAWS and discharge into Lake Michigan. These discharges occur via three control works locations: the Wilmette Pumping Station, the Chicago River Lock and Controlling Works, and the O'Brien Lock and Controlling Works on the Calumet River (Figure 2-4). These discharges from the CAWS to Lake Michigan are of interest because mercury in stormwater and CSO, which discharge into the CAWS, can contribute to the impairment of the Lake Michigan study area waters.

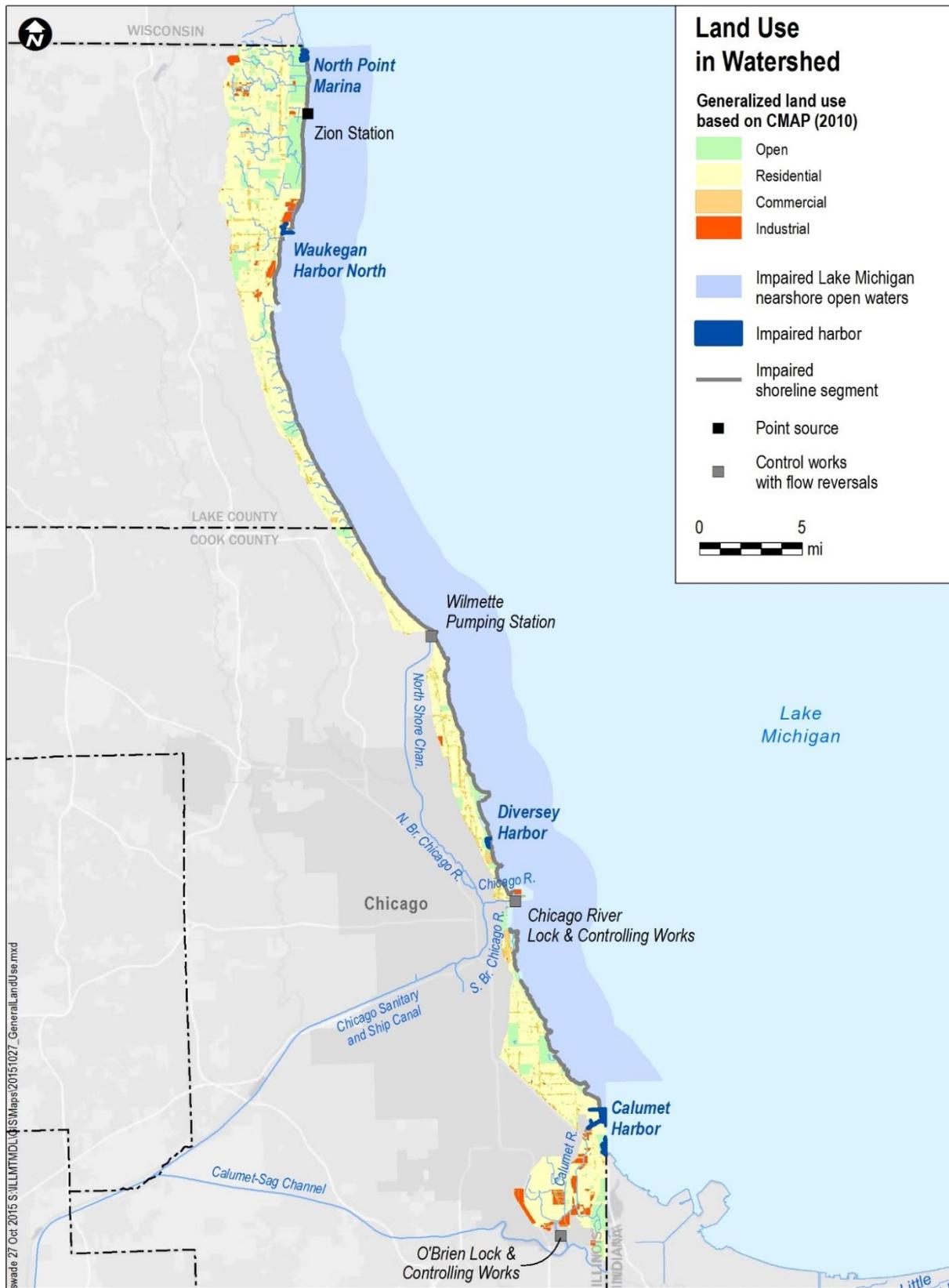


Figure 2-4. Study Area Land Use

## 2.2.2 Impaired Waterbody Description

A total of 56 segments are impaired due to mercury. The impaired nearshore open water segment is 180 square miles in size, extending 5 km into Lake Michigan from the Illinois Lake Michigan shoreline, with Lake Michigan serving as its eastern boundary (Figure 2-3). Additionally, 51 shoreline (beach) segments are identified as impaired due to concentrations of mercury in fish tissue. One segment, Waukegan Harbor North, is also listed as impaired due to mercury concentrations in the water column. The term *shoreline segment* is used in this document, because not all of the segments have beaches. The total length of these shoreline segments is approximately 63.5 miles, with segment lengths ranging from 0.07 to 5.5 miles.

Interspersed with the shoreline segments are four harbors that are impaired due to mercury: Waukegan Harbor North (~0.07 square miles), North Point Marina (~0.12 square miles), Diversey Harbor (~0.05 square miles), and Calumet Harbor (~2.4 square miles). These harbors, shown in Figure 2-5, are described briefly below.

**Waukegan Harbor**, a federally authorized navigation project in Waukegan, Illinois, is used for both industrial and recreational activities. This manmade harbor is approximately 40 miles north of the city of Chicago (IDNR, 2012). The United States Army Corps of Engineers (USACE) has been involved with dredging operations at this harbor since 1889. With the exception of some intermittent harbor deepening projects, the vast majority of the dredging operations have focused on maintaining navigable conditions, primarily within the approach channel (Department of the Army, Chicago District, Corps of Engineers, 2013), which is beyond the extent of the impaired area shown in Figure 2-5. Waukegan Harbor sediments were dredged in 1992 and 1993, and again in 2012 and 2013, to remove PCB-contaminated sediments (USEPA, 2015).

**North Point Marina**, in Winthrop Harbor, Illinois, is the largest marina on the Great Lakes (IDNR, 2015a). **Diversey Harbor** is in Lincoln Park, within Lake Shore Drive. Due to bridge restrictions, Diversey Harbor can only accommodate power boaters (Chicago Harbors, 2015).

**Calumet Harbor** and the Calumet River include an approach channel, an outer harbor channel, an entrance channel, and a river channel. The approach and outer harbor channels are located primarily in Indiana. The entrance channel and river channel are located in Illinois and extend approximately 6.7 miles up the Calumet River to Lake Calumet (USACE Chicago and Rock Island Districts, 2015). Calumet Harbor is a deep draft commercial harbor that is protected by 12,153 linear feet of steel sheetpile and timber crib breakwater structures (USACE Detroit District, 2015). This is the largest of the study area's four impaired harbors, and Calumet Harbor and River are the third busiest port on the Great Lakes by tonnage, moving an annual average of over 14 million tons of commodities (USACE Detroit District, 2015). At Calumet Harbor and River, an average of approximately 50,000 cubic yards of sediment are dredged annually, and this dredging requirement is expected to continue. (USACE Chicago and Rock Island Districts, 2015).



Figure 2-5. Impaired Harbor Segments

## 2.3 Data Compilation and Assessment of Water Quality

Water column, fish, and sediment data collected from 2000 to the present were inventoried, compiled, and reviewed to form the project database for the mercury TMDL. Data were reviewed to ensure they were relevant to the project and met the quality objectives and criteria outlined in the project's Quality Assurance Project Plan (QAPP).

The potentially useful sources of data were identified based on project team knowledge, including much input from IEPA and USEPA staff, internet queries, and communication with agencies and Great Lakes researchers familiar with the project study area. In addition, the project team led a webcast on September 17, 2014, to present the objectives of the study to a much broader audience and to solicit input on additional studies or datasets that could be relevant to this project. The project team followed up on all leads identified as a result of the webcast.

Agencies contacted for data included the USEPA Great Lakes National Program Office (GLNPO); USEPA Office of Research and Development (ORD), Grosse Ile, Michigan; USEPA Superfund Division; USEPA Water Division; IEPA Toxicity Assessment Unit, IEPA Bureau of Water; Illinois Fish Contaminant Monitoring Program; Illinois Department of Natural Resources; Wisconsin Water Science Center of the U.S. Geological Survey (USGS); National Oceanic and Atmospheric Administration (NOAA); Environment Canada; Area of Concern project managers; USACE; U.S. Navy; Waukegan Citizens Advisory Group; North Shore Sanitary District; Illinois Lake Michigan Fisheries Program; and researchers at Loyola University and the University of Iowa.

### 2.3.1 Summary of Data by TMDL Zone

The project database contains fish tissue and sediment data. Fish fillet data are summarized in this section because those are the samples used to support the development of the TMDL. Although one segment of the study area (Waukegan Harbor) is also listed as impaired due to water column concentrations, that listing is based upon older data, which are no longer available. While this section provides data by individual TMDL zone, the TMDL development is based on an approach that allows for the data from all segments to be considered together as in one area.

Sampling locations for all fish and sediment data in the database were paired with impaired segment(s), with input from IEPA, reflecting which sampling stations are located within the impaired segments. The nearshore open water segment was assessed based on samples collected in the nearshore open water segment. The 51 shoreline segments were similarly assessed based on samples collected in the nearshore open water segment. Because the data collected in the nearshore open water were used to assess the nearshore as well as the 51 shoreline segments, these segments are collectively referred to as being within the "nearshore open water/shoreline" TMDL Zone (see Tables 2.1 and 2.2). Each fish sample collected within the impaired harbors was assigned to the appropriate harbor.

Tables 2-1 and 2-2 summarize the number of samples available in the project database for the study area. A count of mercury fillet samples by fish species and TMDL zone is shown in Table 2-1. Table 2-2 presents a count of sediment mercury samples by TMDL zone. Note that there are no water column mercury concentrations available for the study area. The locations at which the mercury fish fillet samples were taken are shown in Figure 2-6.

**Table 2-1. Count of Fish Mercury Fillet Samples by Species and TMDL Zone**

Fish Species	TMDL Zone				Grand Total
	Nearshore open water/ shoreline	Calumet Harbor	North Point Marina	Waukegan Harbor	
<b>Black bullhead</b>	-	-	-	2	2
<b>Brown trout</b>	1	-	-	-	1
<b>Largemouth bass</b>	-	-	3	-	3
<b>Rainbow trout</b>	2	-	-	-	2
<b>Rock bass</b>	-	1	4	4	9
<b>Smallmouth bass</b>	-	5	2	-	7
<b>Sunfish</b>	-	-	3	2	5
<b>White sucker</b>	-	-	2	2	4

**Table 2-2. Count of Mercury Sediment Samples by TMDL Zone**

Media <sup>a</sup>	TMDL Zone				Grand Total
	Nearshore open water/ shoreline	Calumet Harbor	North Point Marina	Waukegan Harbor	
<b>Sediment</b>	-	6	2	4	12

<sup>a</sup> There were no mercury water column samples for study area waterbodies.

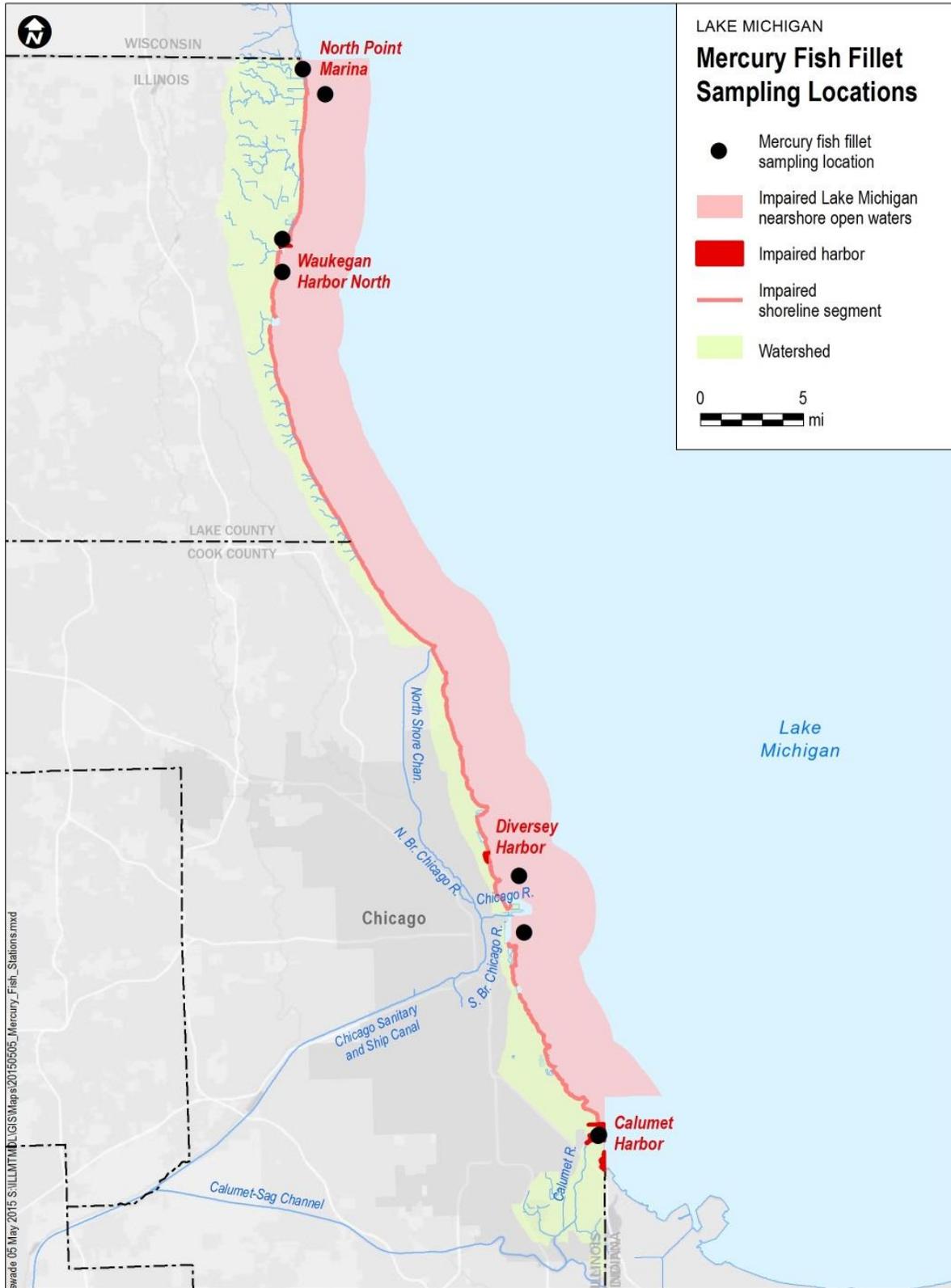


Figure 2-6. Sampling Locations for Mercury Fish Fillets

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# 3

## Applicable Water Quality Standards and TMDL Targets

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This section describes relevant WQS, designated use support, and numeric TMDL targets for mercury.

### 3.1 Water Quality Standards

The Clean Water Act Section 303(c)(2)(A) requires states to designate appropriate water uses for all waterbodies, and adopt WQS for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water. Designated uses describe the various uses of waters that are considered desirable, and identify those waters that should be protected. Some examples of designated uses are primary contact (such as swimming and water skiing), fish consumption, aquatic life, and aesthetic quality. Surface waters in Illinois fall into one of four categories: General Use, Public and Food Processing Water Supplies, Secondary Contact and Indigenous Life, and Lake Michigan Basin (IEPA, 2014). Each category has its own set of water quality standards. The standards for the Lake Michigan Basin are found in the Illinois Administrative Code (35 IAC 302.501-595 Subpart E). Some of the Lake Michigan Basin WQS apply to all waters within the basin, while others apply only to the open waters of the Lake or only to tributary waters of the Lake. WQS for the Lake Michigan Basin protect aquatic life, human health, wildlife, and recreational uses. Waters of the Lake Michigan Basin must be free from any substance or any combination of substances in concentrations toxic or harmful to human health, or to animal, plant, or aquatic life (35 IAC 302.540). Lake Michigan Basin waters include all tributaries of Lake Michigan, harbors, and open waters of the Illinois portion of the lake. Numeric water quality criteria are developed to protect the designated uses of surface waters, and the standards for mercury are described below.

The WQS for mercury in surface waters of the Lake Michigan basin are 0.0013 µg/L (or 1.3 ng/L) for the protection of wildlife, 0.0031 µg/L (or 3.1 ng/L) for the protection of human health, and 1,700 ng/L (1.7 µg/L) and 910 ng/L (0.91 µg/L) for the protection of aquatic life from adverse effects due to acute and chronic toxicity, respectively [35 IAC 302.504(e)]. These standards were adopted by the State of Illinois as part of the Great Lakes Water Quality Initiative (GLI) and apply to all waters of the Lake Michigan Basin.

### 3.2 Designated Use Support

Every two years, the State of Illinois evaluates the extent to which waters of the state are attaining their designated uses. The degree of support of a designated use in a particular area (assessment unit) is determined by an analysis of biological, physicochemical, physical habitat, toxicity, and other data. When sufficient data are available, each applicable designated use in each assessment unit is assessed as *Fully Supporting* (good), *Not Supporting* (fair), or *Not Supporting* (poor). Waters in which at least one applicable use is not fully supported are considered impaired.

Fish consumption use is associated with all waterbodies in the state. The assessment of fish consumption use is based on (1) waterbody-specific fish-tissue data and (2) fish-consumption advisories issued by the

multi-agency<sup>4</sup> Illinois FCMP, which consists of staff from the departments of Agriculture, Natural Resources, Public Health, the Illinois Emergency Management Agency, and IEPA. The FCMP uses a risk-based process developed in the Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory (Anderson et al., 1993). The Protocol requires the determination of a Health Protection Value (HPV) for a contaminant, which is then used to calculate the level of contaminant in fish tissue that will be protective of human health at several meal consumption frequencies (ranging from unlimited consumption to “do not eat”). This information is used to calculate the level of the contaminant in fish that will not result in exceeding the HPV at each meal consumption frequency.

For mercury, the HPV for fish consumption by sensitive populations (includes pregnant or nursing women, women of child-bearing age, and children under the age of 15) is 0.10 µg/kg/day. The HPV for women beyond child-bearing age and men over the age of 15 is 0.30 µg/kg/day. Based on the 0.10 µg/kg/day HPV, the lowest fish tissue concentration that would result in a fish consumption advisory is 0.06 mg/kg for all species; this is, therefore, the concentration used to assess support of the fish consumption use. The 0.06 mg/kg fish tissue concentration, which is a risk-based advisory concentration developed from an extensive database of studies of the health effects of methyl mercury, is used by the Fish Contaminant Monitoring Program as the starting point for issuing a “one meal per week” advisory. This concentration was derived by the Great Lakes Fish Advisory Task Force and accepted by the Great Lakes states for use in their sport fish advisory programs. It should be noted that this fish tissue assessment concentration was derived independently of the numeric water column criteria.

While there is a statewide fish consumption advisory for mercury because of widespread contamination above criteria levels throughout the state, not all waterbodies have been sampled, and not all samples exceeded criteria levels. For mercury, fish consumption use is assessed as *Not Supporting* only for specific waters where at least one fish-tissue sample is available and where at least one fish species exceeds the 0.06 mg/kg criterion for mercury. Also, because the statewide advisory is for predator species, fish consumption use is only assessed as *Fully Supporting* in those waters where predator fish-tissue data from the most recent two years do not show mercury contamination above criteria levels. Waters where sufficient fish-tissue data are unavailable are considered *Not Assessed*.

Aquatic life uses are assessed using the three most recent years of available data. For Lake Michigan open waters and harbors, if two or more samples exceed the acute aquatic life criterion, the waters are considered impaired. If more than 10 percent of the samples exceed the chronic aquatic life criterion, the waters are considered impaired.

### 3.3 Numeric TMDL Targets

TMDL targets are established at a level that attains and maintains the applicable WQS, including designated uses, numeric and narrative criteria, and antidegradation policy [40 CFR §130.7(c)(1)]. TMDL submittals must include a description of any applicable water quality standard, and must also identify numeric water quality targets, which are quantitative values used to measure whether or not applicable WQS are being attained. Depending on the designated use being addressed, a TMDL target may be based on human health, aquatic life, or wildlife criteria. Where possible, the water quality criterion for the pollutant causing impairment is used as the numeric water quality target when developing the TMDL. Because all of the assessment units addressed in this TMDL are impaired for the fish consumption use, the HPV for fish consumption for sensitive populations was used to derive the TMDL target of 0.06 mg/kg for mercury.

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<sup>4</sup> From Illinois Department of Public Health website Factsheet “Fish Advisories in Illinois”

This TMDL needs to demonstrate that compliance with the fish tissue TMDL target will also meet the water quality targets, including the human health and wildlife criteria described above (for all waters), and additionally for Waukegan Harbor, meet the aquatic life criteria. This has been accomplished via the application of published bioaccumulation factors (BAFs) for the Great Lakes, which provide a translator between pollutant concentration in the water column and resulting fish tissue contamination (USEPA, 1995). The water column concentration corresponding to the fish tissue TMDL target of 0.06 mg/kg mercury was calculated to equal 0.43 ng/L. This is lower (more stringent) than the most stringent WQS for mercury (1.3 ng/L) for wildlife, indicating that use of the fish tissue concentration as the TMDL target will result in water column concentrations that will comply with applicable water quality criteria to protect human health and wildlife. This apparent discrepancy in water column targets is due to the previously discussed fact that the fish tissue assessment concentration was derived independently of the numeric water column criteria

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# 4

## Source Assessment

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The purpose of a source assessment is to consider all potential sources of the pollutant of concern, in order to quantify source reductions that are needed to attain designated uses. The sources that were investigated and their estimated load contributions are discussed in this section.

This TMDL was developed using a direct proportionality approach that allows for the data for the whole study area to be considered together to establish a TMDL that is appropriate for the entire study area. The approach is further described in Section 5.

A number of source categories were evaluated as potential sources of mercury to the study area:

- Hydrodynamic transport
- Atmospheric loading
- MS4 stormwater loading
- Flow reversals from the CAWS
- Other point source discharges

As described below, the most significant sources were found to be hydrodynamic transport of mercury from the open water of Lake Michigan and atmospheric loading.

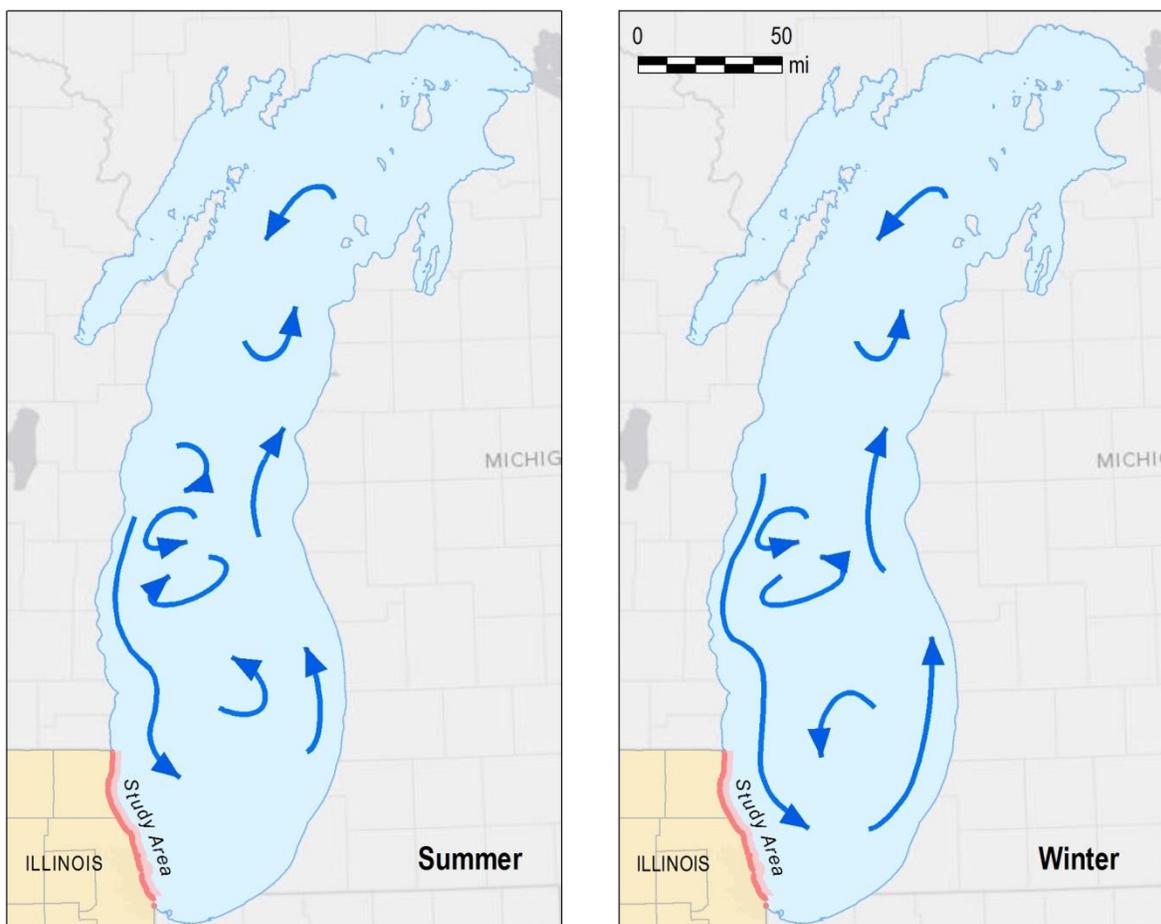
### 4.1 Hydrodynamic Transport

The open water of Lake Michigan is a source of mercury to the project study area. As described below, the predominant flow patterns in Lake Michigan circulate counter-clockwise in the vicinity of the study area (Beletsky and Schwab, 2001; Beletsky et al., 1999). As such, mercury loads to the study area can be estimated using the flow into the study area and Lake Michigan mercury concentrations at the northern end of the study area.

Hydrodynamic transport between Lake Michigan and the nearshore open water segment was estimated for this project using the NOAA Great Lakes Coastal Forecasting System (GLCFS). The GLCFS is a set of models that simulate and predict the two- and three-dimensional structure of currents, temperatures, winds, waves, and ice in the Great Lakes using a 4-km<sup>2</sup> (2 km x 2 km) grid size. The GLCFS uses a modified Princeton Ocean Model, developed by NOAA's Great Lakes Environmental Research Laboratory and the Ohio State University, and is supported by the National Weather Service (NOAA, 2015).

Results from the GLCFS were used to estimate the transfer of mercury into the study area. This was first accomplished by estimating the annual average flow of Lake Michigan water into the study area. GLCFS modeling results were extracted for the northern edge of the study area, as the predominant lake current is in this direction. Figure 4-1 shows the mean circulation, adapted from Beletsky and Schwab (2001). The mean current speed from the north was 3.35 cm/s for 2014. The area of conveyance for this velocity is 54,000 m<sup>2</sup>, which was calculated by multiplying the average depth of the first two GLCFS model grid cells (10 m and 17 m) by the width of each cell (2 km each). Multiplying the average speed by the area determined an average flow into the study area of 1,810 m<sup>3</sup>/s. Mercury concentrations from the main body of Lake Michigan (USGS, undated), measured outside the study area, averaged 0.18 ng/L. Multiplying this

concentration by flow would equal 10.3 kg/yr of mercury entering the study area due to transport from Lake Michigan. It is important to note that atmospheric deposition is the dominant source of mercury into the main body of Lake Michigan, such that reductions attained through this TMDL to control atmospheric loads will also help control loading from Lake Michigan.



**Figure 4-1. Observed Mean Circulation in Lake Michigan (Adapted from Beletsky et al., 1999 cited in Beletsky and Schwab, 2001)**

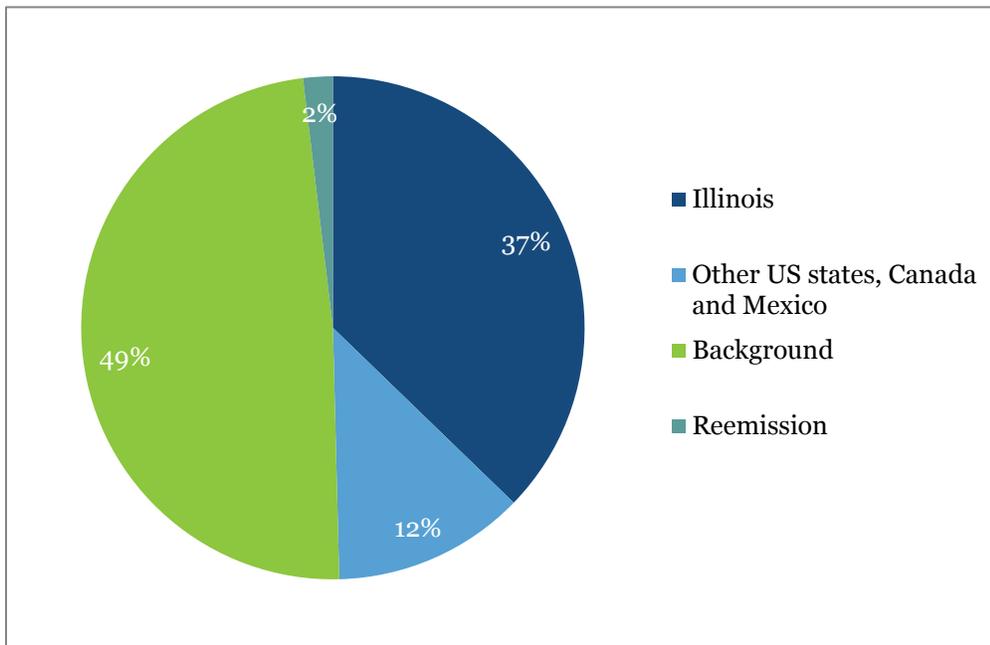
## 4.2 Atmospheric Deposition

Atmospheric mercury loading to terrestrial and aquatic water surfaces occurs via wet and dry deposition. Sources of mercury that contribute to atmospheric loadings to the Illinois Lake Michigan nearshore are natural sources from geologic origins, re-emissions, and anthropogenic sources.

The total atmospheric mercury deposition across the nearshore open waters and harbors of the study area was obtained from USEPA's Regional Modeling System for Aerosols and Deposition (REMSAD; USEPA, 2008). REMSAD is a "three-dimensional grid model designed to calculate the concentrations of both inert and chemically reactive pollutants by simulating the physical and chemical processes in the atmosphere that affect pollutant concentrations" (USEPA, 2008). REMSAD simulates both wet and dry deposition of mercury. Wet deposition occurs as a result of precipitation scavenging, in which mercury is removed from the air by becoming attached to water vapors or rain/snow. Dry deposition occurs when gas phase (i.e., absorption of reactive gaseous mercury) and particulate-bound mercury are deposited on terrestrial and aquatic surfaces. The Particle and Precursor Tagging Methodology feature of REMSAD allows the user to

tag or track emissions from selected sources or groups of sources, and to quantify their contributions to mercury deposition throughout the modeling domain and simulation period.

The REMSAD model estimated that in 2001<sup>5</sup>, the mass of mercury deposited to the study area (i.e., Lake Michigan nearshore) through total atmospheric deposition was 23 kg/yr. Illinois sources contribute 37 percent of the atmospheric mercury deposition to the study area (Figure 4-2; Table 4-1). Regional sources, which include other U.S. states, Canada, and Mexico, contribute 12 percent of the mercury deposition. About 49 percent of the atmospheric mercury deposition to the project study area originated from background sources. *Background* refers to natural sources, as well as anthropogenic sources outside of North America. The remaining 2 percent of mercury deposition comes from re-emission, defined as previously deposited mercury that has been volatilized from water, land, or vegetation.



**Figure 4-2. Distribution of Sources of Atmospheric Mercury Deposition to Illinois (Source: USEPA, 2015a)**

<sup>5</sup> The REMSAD model was applied at a national scale. The year 2001 was chosen as the annual simulation year because REMSAD model inputs (emissions and meteorology) were primarily derived from the 2001 Clean Air Interstate Rule (CAIR) database, which USEPA used in the evaluation of the CAIR and the Clean Air Mercury Rule (CAMR).

**Table 4-1. Atmospheric Mercury Load by Source Category for Illinois, Surrounding States, Canada, and Mexico (Source: USEPA, 2015a)**

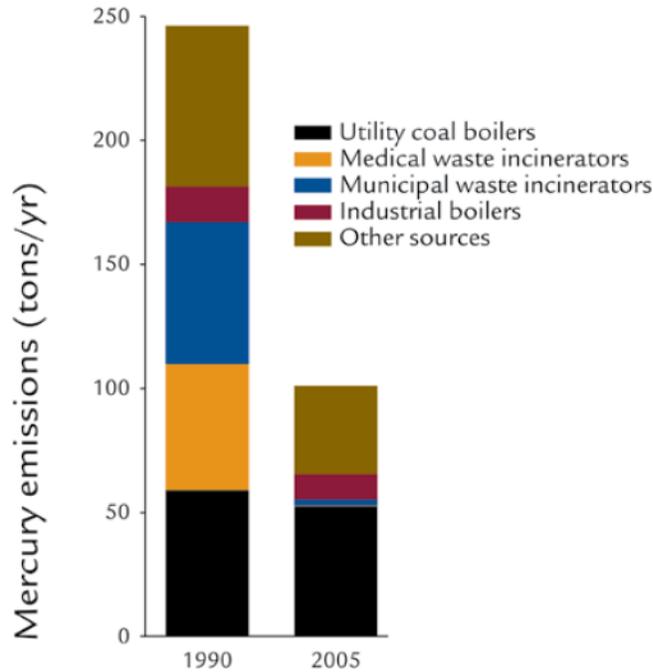
Source Category of Atmospheric Mercury	Load (kg)	Load (lbs)	% Load
<b>Background</b>	11.27	24.86	49%
<b>Re-emission</b>	0.44	0.97	2%
<b>Illinois</b>	8.66	19.08	37%
<b>Loading from other U.S. states, Canada, and Mexico</b>	2.87	6.33	12%
<b>Total</b>	23.24	51.24	100%

#### 4.2.1 Natural Sources

As explained in Section 2.1, natural sources of mercury include mercury emitted from geothermal sources, volcanic eruptions, and the weathering of mercury-containing rocks. There are no known natural sources of mercury in Illinois, unlike in other parts of the United States, such as California, where certain mountain ranges are rich in cinnabar deposits. Re-emission of previously deposited mercury can occur from vegetation, land, and water surfaces. Meteorological conditions and activities related to land use changes and biomass burning can enhance the re-emission process (Pirrone et al., 2010). Land use changes associated with deforestation and surface disturbances related to agricultural activities release soil mercury and contribute to re-emission.

#### 4.2.2 Anthropogenic Sources

Anthropogenic sources of mercury are varied and widespread; most mercury emissions are attributed to a combustion source. In 1990, coal-fired power plants, municipal waste combustors, and medical waste incinerators were the three largest mercury emission source categories in the United States (Schmeltz et al., 2011; Evers et al., 2011). In the late 1990s, regulatory controls were imposed on municipal waste combustors and medical waste incinerators. As a result, mercury emissions from municipal waste combustors and medical waste incinerators declined by more than 90 percent in 2005, relative to 1990 levels. Between 1990 and 2005, anthropogenic mercury emissions in the United States declined by approximately 59 percent, largely due to controls on municipal and medical waste incinerators (Figure 4-3). Mercury emissions from power plants remained relatively unchanged during this time. Currently, coal-fired power plants are the single largest source of mercury emissions nationwide and in Great Lakes region (Evers et al., 2011; Schmeltz et al., 2011).



**Figure 4-3. Total U.S. Anthropogenic Mercury Emissions (Source: Evers et al., 2011)**

In Illinois, the largest source category of anthropogenic mercury emissions is coal-fired electric utilities. Using 2002 data from the National Emissions Inventory (NEI), the coal-fired electric utilities contributed over 70 percent of the total airborne mercury emissions in the state (Figure 4-4). Other notable source categories include mercury emissions from primary and secondary metal production; various industrial processes; fuel combustion for industrial, commercial, and residential purposes; waste incinerators including hazardous and medical waste combustors; and cement and lime manufacturing.

### 2002 Illinois Anthropogenic Mercury Emissions (6.04 tons)

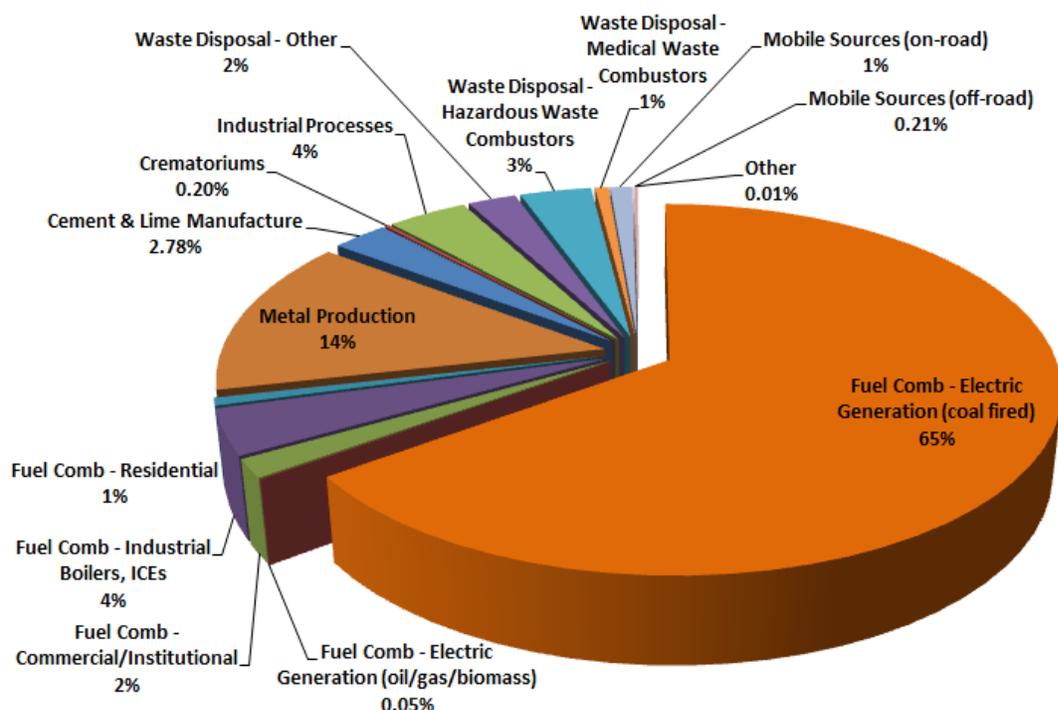


Figure 4-4. 2002 Total Anthropogenic Mercury Emissions to the Atmosphere from Illinois (Source: NEI, 2002)

### 4.3 MS4 Stormwater Mercury Loading

In addition to the fact that Lake County, Shields Township, Waukegan Township, and the Cook County Highway Department have MS4 permits, 93.5 percent of the study area watershed lies within an MS4 city (including Chicago) or village. As a result, close to 100 percent of the study area is within an MS4 area. However, no site-specific data were available to quantify stormwater mercury loads for the study area watershed (MWRDGC, 2015). The magnitude of stormwater mercury loads was, therefore, estimated as the product of runoff, the study area drainage area, and an assumed mercury concentration, based on stormwater sampling outside the study area watershed. It was also conservatively assumed that all of the runoff generated within the study area watershed drains to Lake Michigan. The development of these inputs is described below.

Runoff quantity was calculated using the method developed by the Metropolitan Washington Council of Governments (Schueler, 1987) as:  $R = P * P_j * R_v$

Where:

R = Annual runoff (inches),

P = Annual rainfall (inches) estimated as 36.1 inches, based on the average annual rainfall reported for Chicago Midway Airport 3 SW for the 1929-2013 period ([http://www.crh.noaa.gov/lot/?n=111577\\_Midway](http://www.crh.noaa.gov/lot/?n=111577_Midway))

P<sub>j</sub> = Fraction of annual rainfall events that produce runoff (set to the default of 0.9)

$R_v$  = Runoff coefficient.  $R_v$  is a function of impervious cover in the study area watershed. Impervious cover was calculated using Geographic Information System (GIS) analysis for each major land use category: commercial (0.71), industrial (0.54), and residential (0.37). The following runoff coefficients resulted from these impervious cover values: commercial (0.69), industrial (0.54), and residential (0.38)

The area of the contributing watershed was calculated as 99.6 square miles, broken down as 3.82 square miles commercial, 4.05 square miles industrial, and 91.73 square miles residential.

The mercury concentration was based on USGS stormwater measurements for the Columbia River Basin, Washington, and Oregon (2009-2010) (Morace, 2012). The value used for load calculation was based on the average of reported values for total mercury, which equaled 37.17 ng/L. The estimated stormwater mercury load equaled 6.96 lbs/year (3.16 kg/yr).

#### 4.4 Mercury Loading from Flow Reversals from the Chicago Area Waterway System

The CAWS is a 76.3-mile branching network of navigable waterways controlled by hydraulic structures. The CAWS flow is composed of treated sewage effluent, CSO, and stormwater runoff, and the dominant uses are for conveyance of treated municipal wastewater, commercial navigation, and flood control. Flows from the CAWS ultimately drain to the Mississippi River, but on occasion, flows are reversed and flow into Lake Michigan.

There are two types of reversals: gate reversals and lock reversals. Gate reversals occur adjacent to the lock structure and involve small volumes of water. Lock reversals occur when the locks are opened during severe storms. Lock reversals allow a much greater volume of water to flow into Lake Michigan. During particularly large storms, lock reversals allow flow from the CAWS to discharge to Lake Michigan through the control works shown in Figure 2-4 (O'Brien Lock, Chicago River Lock, and Wilmette Lock).

Limited site-specific data were available to quantify the magnitude of mercury loads from the CAWS flow reversals. The magnitude of loads entering the study area waters from periodic flow reversals of the CAWS was estimated based on measured flow and site-specific concentration data, as described below. Because this estimate was uncertain, a second load calculation is provided, using site-specific flow data and mercury measurements from another location.

The volume of flow is reported by the Metropolitan Water Reclamation District of Greater Chicago (MWRD) on their website

[http://www.mwrdd.org/irj/go/km/docs/documents/MWRD/internet/protecting\\_the\\_environment/Combined\\_Sewer\\_Overflows/pdfs/Reversals.pdf](http://www.mwrdd.org/irj/go/km/docs/documents/MWRD/internet/protecting_the_environment/Combined_Sewer_Overflows/pdfs/Reversals.pdf) Until recently, the MWRD conducted water quality sampling in the CAWS during flow reversals, including measurements of mercury. Mercury loads to the study area from flow reversals were initially calculated based on mercury concentration data collected at approximately 30-minute intervals during the 2013 flow reversals at each of these three locations (Table 4-2), and the average 2010-2014 annual volume (4,021.4 million gallons). Because all mercury concentration measurements were lower than the levels of detection, loads from this source could not be accurately characterized using site-specific concentration data.

**Table 4-2. Measured CAWS Mercury Concentrations During Times of Flow Reversals**

Location	Location of mercury sampling	Mercury results (4/18/13)
<b>O'Brien Lock</b>	Calumet Harbor, 95 <sup>th</sup> St. Bridge; Calumet Harbor, Ewing Ave. Bridge	All 68 samples < 0.2 ug/L
<b>Chicago River Lock</b>	Chicago River Locks, Inner Harbor Sluice Gate; Chicago River Locks, Sluice Gate, DuSable Harbor	All 28 samples < 0.2 ug/L
<b>Wilmette Lock</b>	Wilmette Harbor, Wilmette Pump Station	All 12 samples < 0.2 ug/L

Instead, mercury loads from flow reversals were roughly estimated to be 0.56 kg/yr, using reported MWRD flow volumes and Columbia River stormwater concentrations (37.17 ng/L). The availability of mercury measurements for CSOs was investigated; however, mercury concentrations are not measured for CSOs in the study area (MWRDGC, 2015a).

#### 4.5 Other Point Source Mercury Discharges to the Study Area

There are no facilities with National Pollutant Discharge Elimination System (NPDES) mercury permit limits or mercury effluent monitoring requirements within the study area (other than permitted MS4s). Therefore, the mercury load from other permitted point source dischargers was assumed to equal zero.

#### 4.6 Summary

Hydrodynamic transport of mercury from the main body of Lake Michigan and atmospheric loading are clearly important loading sources (Table 4-3). No definitive determination could be made for stormwater loading, other point source discharges, or flow reversals from the CAWS, because site-specific mercury concentration data were either below detection limits or not available. While literature-based estimates for these sources indicate that they are likely to be minor contributors to the study area as a whole, they have the potential to be significant contributors to individual harbors.

**Table 4-3. Mercury Loads to the Study Area**

Process	Data Sufficiency <sup>a</sup>	Estimated Magnitude
<b>Hydrodynamic transport from main body of Lake Michigan</b>	Acceptable	10.3 kg/yr
<b>Atmospheric Loading</b>	Acceptable	23.24 kg/yr
<b>MS4 Stormwater Loading</b>	Limited. Rough estimate made using literature-based concentrations	3.16 kg/yr
<b>Flow Reversals from the Chicago Area Waterways</b>	Limited. All available data are non-detectable; Rough estimate made using literature-based concentrations	0.56 kg/yr

<sup>a</sup> Site-specific data sufficiency is characterized as limited (indicating the use of literature values and/or measurements less than the detection level) for the majority of the processes of concern, with hydrodynamic transport and atmospheric loading being the only sources that can be quantified with existing data.

# 5

## Modeling Approach

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A wide range of modeling frameworks exist that could potentially be used to support development of the Illinois Lake Michigan nearshore mercury TMDL. The TMDL Scoping Report (LimnoTech, 2015) reviewed the range of available frameworks and concluded that a zero-dimensional, steady state proportionality approach was most appropriate for this project, given the amount of data available to support TMDL development. This section describes the modeling approach for calculating the mercury TMDL. It consists of the following sections:

- Fish-tissue based approach
- Required reduction percentage

### 5.1 Fish Tissue-Based Approach

The approach for linking pollutant loads directly to fish tissue concentrations for this TMDL was patterned after the statewide mercury TMDL developed by the Minnesota Pollution Control Agency (MPCA, 2007), which drew from the work of Jackson et al. (2000), a regional mercury TMDL for the Northeast United States (CDEP et al., 2007), and a statewide mercury TMDL report for Michigan (LimnoTech, 2013).

This approach is based on the following assumptions: 1) a reduction in mercury emissions will result in a proportional reduction in the rate of mercury deposition; 2) a reduction in mercury deposition will result in a proportional decrease in mercury loading to water bodies; and 3) ultimately, a proportional reduction in loading in water bodies will result in a proportional decrease in mercury concentrations in fish.

The proportionality approach is based on the linear relationship between mercury levels in air and water, along with a bioaccumulation factor (BAF) to relate fish tissue concentrations to water column concentrations. The mercury concentrations in fish resulting from the mercury bioaccumulation process can be expressed as shown in Equation 5-1 (USEPA, 2001; CDEP et al., 2007):

$$C_{fish_{t_1}} = BAF * C_{water_{t_1}} \quad (5-1)$$

Where:

$C_{fish_{t_1}}$  and  $C_{water_{t_1}}$  represent mercury concentrations in fish (mg/kg) and water (mg/l) at time  $t_1$ , respectively. BAF represents the bioaccumulation factor, which is constant.

For a future time,  $t_2$ , when mercury concentrations have changed, but all other parameters remain constant, equation 5-2 applies:

$$C_{fish_{t_2}} = BAF * C_{water_{t_2}} \quad (5-2)$$

Where:

$C_{fish_{t_2}}$  and  $C_{water_{t_2}}$  represent mercury concentrations in fish and water at that future time  $t_2$ , respectively, and  $C_{fish_{t_2}}$  is for a fish that is the same age, length, and species as for  $C_{fish_{t_1}}$ .

Combining the two equations produces equation 5-3:

$$\frac{C_{fish_{t_1}}}{C_{fish_{t_2}}} = \frac{C_{water_{t_1}}}{C_{water_{t_2}}} \quad (5-3)$$

Because water column mercury concentrations are proportional to mercury air deposition load, the above equation can be expressed as shown in equation 5-4:

$$\frac{C_{fish_{t_1}}}{C_{fish_{t_2}}} = \frac{L_{air_{t_1}}}{L_{air_{t_2}}} \quad (5-4)$$

Where:

$L_{air_{t_1}}$  and  $L_{air_{t_2}}$  are the air deposition mercury loads to the waterbody at time  $t_1$  and  $t_2$ , respectively.

Thus, it is reasonable to predict that, under long-term steady-state conditions and a linear relationship assumption, mercury fish concentrations will likely be reduced from current levels in direct proportion to reductions in the deposition load.

The steady state conditions represented in the model correspond to long-term average concentrations expected to eventually occur in response to long-term reduction in loading. Therefore, it is not expected that the proportional relationship between atmospheric deposition reductions and fish tissue reductions will be observed immediately. However, it is expected that the proportional response will be seen over the long term, once the systems have achieved a steady state. Several dynamic ecosystem scale models, including the Mercury Cycling Model (MCM) and IEM-2M model, assume that, at steady state, reductions in fish concentrations will be proportional to reductions in mercury inputs (USEPA, 2001). Application of the E-MCM<sup>6</sup> model to the Florida Everglades predicted a linear relationship between atmospheric mercury deposition and mercury concentrations in largemouth bass (Atkeson et al., 2003). In this study, mercury levels in largemouth bass were predicted to attain 50 percent of their long-term steady state response in about 10 years, given continued reductions in mercury loads. In 30 years, mercury levels in largemouth bass are predicted to attain 90 percent of their long-term steady state response.

Application of the fish tissue-based approach requires the selection of a target concentration (Section 3.3), an appropriate fish species, and calculation of a reduction percentage, also referred to as a reduction factor (RF).

### 5.1.1 Selection of a Target Fish Species

Fish tissue mercury concentrations have been sampled in a wide range of species across the study area, and they show varying degrees of bioaccumulation. The use of fish tissue samples from multiple species to form the basis for compliance with the fish consumption advisories incorporates these varying degrees of bioaccumulation across the study area into the assessment for impairment of the fish consumption designated use.

The available fish tissue mercury concentration data for 33 samples across 8 species of fish, spanning the collection period of 2000 to 2012, were used in the evaluation. The distribution of concentrations suggests that largemouth bass have the highest mean mercury concentrations of these species (Table 5-1). All three largemouth bass tissue samples were collected in North Point Marina. Largemouth bass have a mean

<sup>6</sup> E-MCM is the modified version of MCM developed for the Florida Everglades.

mercury concentration of 0.28 mg/kg. Largemouth bass was selected as the target species for this TMDL because it represents a top-predator species and has the highest mean mercury concentrations of the fish species evaluated.

Due to the lack of data from several harbors and the nearshore open water/shoreline zone, TMDL calculations require the extrapolation of fish data across sites to account for the absence/limited number of fish samples in certain TMDL zones. Although only three samples exist for largemouth bass, and all from a single marina, their use as a target species is reasonable given the data available.

**Table 5-1. Mean Fish Fillet Mercury Concentration (mg/kg) across Entire Study Area**

Species	Count	Mean (mg/kg)
Largemouth Bass	3	0.2800
Smallmouth bass	7	0.1096
Rock Bass	9	0.1023
White sucker	4	0.0528
Sunfish	5	0.0328
Black bullhead	2	0.0550
Rainbow trout	2	0.0638
Brown Trout	1	0.1030

## 5.2 Required Reduction Percentage

The calculation of the reduction percentage, or reduction factor (RF), is based on the load reductions necessary to achieve the target fish tissue mercury concentration, compared to the existing mean mercury concentration in fish tissue (Equation 5-5).

$$\% \text{ Reduction} = \frac{(C_{fish,current} - C_{fish,target})}{C_{fish,current}} \quad (5-5)$$

Where:

$C_{fish,current}$  = Current mercury concentrations in fish (mg/kg)

$C_{fish,target}$  = Target mercury concentrations in fish (mg/kg)

Equation 5-5 was applied using the average mercury concentration of all largemouth bass (0.28 mg/kg) in conjunction with the fish tissue target of 0.06 mg/kg to calculate a required load reduction of 78.57 percent.

The year 2001 was used for calculating reductions, based on the availability of the atmospheric deposition modeling results from REMSAD (Section 4.2). A 2002 mercury emissions inventory baseline will be used to track reduction progress, because IEPA does not have a 2001 emissions inventory for mercury and it is likely that the deposition values did not change significantly between 2001 and 2002.

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## 6

## TMDL Development

A TMDL calculates the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet the WQS for that particular pollutant, in this case for mercury. The TMDL allocates the maximum allowable load to point sources (Wasteload Allocation, or WLA), and nonpoint sources (Load Allocation, or LA), which include both anthropogenic and natural background sources of the pollutant. TMDLs must also include a margin of safety (MOS) to account for uncertainty in the relationship between pollutant loading and receiving water quality, and account for seasonal variations.

The TMDL is typically defined by the following equation:

$$\text{TMDL} = \sum \text{LA} + \sum \text{WLA} + \text{MOS} \quad (6-1)$$

Where:

TMDL = total maximum daily load (i.e., the loading capacity (LC) of the receiving water)

$\sum \text{LA}$  = sum of all load allocation for nonpoint sources

$\sum \text{WLA}$  = sum of all wasteload allocation for point sources

MOS = Margin of safety

The process to determine the TMDL includes:

- 1) Determine the LC of the receiving water(s) (i.e., the maximum pollutant load that the waterbody can assimilate and attain WQS)
- 2) Allocate this loading capacity among the three categories shown in Equation 6-1.

Equation 6-2 is used to calculate the TMDL using the existing combined load of mercury from point and nonpoint sources, defined as the “baseline load”, and the reduction factor (RF):

$$\text{TMDL} = \text{Baseline Load} * (1-\text{RF}) \quad (6-2)$$

Where TMDL is the total maximum daily load as an annual load (kg/yr); baseline load is the total source load during the baseline year of 2001 (including all air sources and NPDES-permitted discharges of mercury); and RF is the reduction factor. The RF is based on the reductions needed to achieve target fish mercury concentrations (see Equation 5-5 in Section 5.2). An annual load is the most appropriate way to calculate this mercury TMDL, because the goal is to address long-term mercury bioaccumulation, rather than track short-term effects. Nonetheless, TMDLs are recommended to be expressed in daily units whenever feasible. Consistent with the Michigan statewide mercury TMDL report (LimnoTech, 2013), a maximum allowable daily load can be estimated by dividing the annual load by 365 (MPCA, 2007, CDEP et al., 2007) (Equation 6-3).

$$\text{TMDL (kg/day)} = [\text{TMDL (kg/day)}] / 365 \quad (6-3)$$

This section presents the calculation of the TMDL, and is divided into the following sections:

- Baseline mercury load
- TMDL loading capacity
- Wasteload allocation
- Load allocation
- Margin of safety
- Critical conditions and seasonal variation

## 6.1 Baseline Mercury Load

The baseline load is the sum of the existing nonpoint and point source loads of mercury for the baseline year. As discussed in Section 5.2, the year 2001 was selected as a baseline year, based on the availability of atmospheric modeling results for 2001.

Point sources of mercury consist of regulated wastewater and stormwater discharges (including permitted municipal separate storm sewer system (MS4) discharges). Stormwater regulated under the NPDES stormwater program (i.e., Phase I and Phase II) is a point source. No detectable mercury concentrations were available for any of the NPDES discharges in the study area, and the source assessment conducted in Section 4 indicted that these sources are likely a small contributor to existing mercury loads to the segment. As such, point sources are not included in the baseline LA. Point sources will receive a WLA, however, to ensure that future loads do not lead to a WQS violation.

Diffuse, or nonpoint, sources of mercury to the study area consist almost entirely of atmospheric deposition, either directly to the study area via atmospheric deposition or indirectly to the main body of Lake Michigan, with subsequent transport into the study area. Table 4-3 indicates that mercury loading due to hydrodynamic transport to the study area from the main body of Lake Michigan was 10.27 kg of mercury per year, while direct atmospheric deposition to the study area contributed 23.24 kg/yr. The sum of these numbers, 33.51 kg/yr, represents the nonpoint source load for the baseline year of 2001.

The nonpoint source load includes contributions from natural and anthropogenic sources of mercury deposition. The Minnesota Mercury TMDL (MPCA, 2007) assumed that mercury deposition is 30 percent natural and 70 percent anthropogenic in origin. These proportions were based on an inferred pre-industrial deposition rate of 3.7  $\mu\text{g}/\text{m}^2$  (from Swain et al., 1992), relative to the total atmospheric deposition of 12.5  $\mu\text{g}/\text{m}^2$  for Minnesota in 1990. The pre-anthropogenic deposition of 3.7  $\mu\text{g}/\text{m}^2$  used in the Minnesota TMDL was also consistent with the value of 3.1  $\mu\text{g}/\text{m}^2$  inferred from a Lake Michigan study showing consistency between different venues of research (Rossmann, 2010). The atmospheric deposition rate for the Lake Michigan nearshore study area in 2001 is 32.1  $\mu\text{g}/\text{m}^2$ , based on REMSAD modeling results. The difference in atmospheric deposition rates between Minnesota (12.5  $\mu\text{g}/\text{m}^2$ ) and the Illinois Lake Michigan nearshore (32.1  $\mu\text{g}/\text{m}^2$ ) results in a higher anthropogenic percentage for the Illinois Lake Michigan nearshore than Minnesota. For the Illinois Lake Michigan nearshore TMDL, mercury deposition is assumed to be 12 percent natural and 88 percent anthropogenic (since 3.7  $\mu\text{g}/\text{m}^2$  is 12 percent of 32.1  $\mu\text{g}/\text{m}^2$ ). Applying these proportions to the total nonpoint source loads, the natural and anthropogenic contributions to mercury deposition are estimated as 4.02 kg/yr and 29.49 kg/yr, respectively.

The baseline total source load is the sum of the point source load and the nonpoint source load for 2001. Because the only significant source of mercury is from nonpoint sources, the baseline load for 2001 is equal to the nonpoint source load. The baseline load for 2001 is 33.51 kg/yr (Table 6-1).

**Table 6-1. Baseline Mercury Load for 2001**

Portion of Baseline Mercury Load	Load
Point Source Load	No detectable concentration*
Nonpoint Source Load	33.51 kg/yr
<b>Total Baseline Load (2001)</b>	<b>33.51 kg/yr</b>

\*See discussion above for further explanation

## 6.2 TMDL Loading Capacity

The baseline load described in Section 6.1 and the RF described in Section 5.2 are used to define the TMDL loading capacity by applying the RF to the baseline load, as shown in Equation 6-4.

$$\begin{aligned} \text{TMDL} &= \text{Baseline Load} \times (1 - \text{RF}) \\ 7.18 &= 33.51 \times (1 - 0.7857) \end{aligned} \quad (6-4)$$

Inserting the baseline load (33.51 kg/yr) and RF (78.57 percent) into Equation 6-4 yields a TMDL of 7.2 kg/yr (16 lbs/yr). The daily equivalent load equals the annual load divided by 365, or 0.020 kg/day (0.043 lbs/day). This is the daily allowable load of mercury that, over time, is expected to result in meeting the fish tissue target for mercury of 0.06 mg/kg, and attaining WQS.

## 6.3 Wasteload Allocation

The WLA is defined as the portion of the loading capacity allocated to NPDES-permitted point sources, including MS4 stormwater. Even though point source mercury loads appear to be small compared to current nonpoint source loads, there is no assurance that these loads will remain a relatively minor contributor to the total load after reductions of nonpoint sources occur. To ensure that point sources do not cause or contribute to violation of the water quality standards, the TMDL requires that these sources attain WQS within the discharge itself. Entities with MS4 permits in the project study area are shown in Table 6-2.

The WLA associated with these stormwater discharges is determined by multiplying the magnitude of stormwater flow delivered to the study area from each of these sources (calculated in Section 4.3) by a concentration equal to the WQS in order to convert it to a load. This results in a stormwater MS4 WLA of 0.11 kg/yr (0.0003 kg/day).

**Table 6-2. Study Area Entities with MS4 Permits**

Place Name	MS4 Permit Number	Place Name	MS4 Permit Number
Beach Park	ILR400164	Lake Forest	ILR400367
Chicago	ILR400173	North Chicago	ILR400402
Cook County Highway Department	ILR400485	Shields Township	ILR400123
Evanston	ILR400335	Waukegan	ILR400465
Glencoe	ILR400198	Waukegan Township	ILR400148
Highland Park	ILR400352	Wilmette	ILR400473
Highwood	ILR400353	Winnetka	ILR400476
Kenilworth	ILR400214	Winthrop Harbor	ILR400477
Lake Bluff	ILR400366	Zion	ILR400482
Lake County	ILR400517		

## 6.4 Load Allocation

The LA for nonpoint sources, presented in Table 6-3, is essentially<sup>7</sup> equal to the loading capacity of 0.02 kg/d calculated in Section 6.2. The nonpoint sources of mercury to the study area consist primarily of atmospheric deposition, either directly to the study area via atmospheric deposition or indirectly to the main body of Lake Michigan, with subsequent transport into the study area. The atmospheric deposition component of LA includes both natural and anthropogenic load allocations. Because natural sources of mercury cannot be controlled, the mercury load attributed to natural deposition (4.02 kg/yr, or 0.011 kg/d) is expected to remain the same. Therefore, all necessary LA for atmospheric deposition is achieved by attributing reductions to anthropogenic mercury deposition.

<sup>7</sup> A portion of the loading capacity will be allocated to point sources, but this portion is within the round-off error of load allocation

**Table 6-3. Mercury Load Allocation**

Portion of Load Allocation	Result
<b>Natural Load Allocation</b>	
Transport from Lake Michigan	0.0076 kg/day
Atmospheric Deposition	0.0034 kg/day
<b>Anthropogenic Load Allocation</b>	
Transport from Lake Michigan	0.0060 kg/day
Atmospheric Deposition	0.0027 kg/day
<b>Total Load Allocation</b>	<b>0.020 kg/day</b>

This TMDL only has regulatory authority for mercury originating from within the State of Illinois. For that reason, it is necessary to divide the atmospheric mercury deposition to the study into separate components corresponding to (1) out-of-state sources and (2) within-state sources. As discussed in Section 4.2, the contribution of both in-state and out of state sources of mercury deposition in Illinois is provided by the Regional Modeling System for Aerosols and Deposition (REMSAD) results. “In-state” represents mercury deposition load due to Illinois sources. The “out of state” load is the sum of the remaining categories: other U.S. states, Mexico, Canada, and background sources (including global and natural sources). In-state sources make up 37 percent of the atmospheric mercury load, while out-of-state sources make up the remaining 63 percent.

In addition to considering out-of-state sources, it is important to consider the amount of atmospheric mercury that comes from anthropogenic versus natural sources. Since natural sources are uncontrollable and are expected to remain at the same level, all reductions must come from anthropogenic sources. To calculate the required reductions from anthropogenic sources, the reduction factor of 78.57 percent (Section 5.2) is divided by the percentage of contribution from anthropogenic sources (88 percent). This results in a required reduction in anthropogenic deposition of 89.29 percent.

As stated above, the in-state contribution to total mercury deposition is 37 percent. Since Illinois’ deposition sources are 12 percent natural and 88 percent anthropogenic, this translates to an in-state contribution of 42 percent of the anthropogenic deposition ( $37\% \div 88\% = 42\%$ ). Therefore, the out-of-state share of anthropogenic deposition is 58 percent.

If the TMDL was designed solely to reduce in-state sources, the necessary reductions from these sources would be calculated using Equation 6-5:

$$\% \text{ reduction in in-state deposition} = \text{RF} / (1 - \% \text{ out-of-state anthropogenic contribution}) \quad (6-5)$$

Where:

RF = Required reduction factor in anthropogenic deposition (89.29%)

Given a required RF of 89.29 percent, and an out-of-state anthropogenic contribution of 58 percent, Equation 6-5 indicates that in-state sources would need to be reduced by 213 percent if no reductions were made to out-of-state sources. In-state reductions in mercury atmospheric deposition alone will not achieve the TMDL target. Therefore, this TMDL assumes that reductions from out-of-state sources will be consistent with those required for in-state sources (i.e., an 89.29-percent reduction will be required for both in-state and out-of-state sources).

Atmospheric modeling results are available for the year 2001; however, the emissions inventory is for 2002. Although these years don't match exactly, this information is the best available and is sufficiently close for calculating the TMDL load reductions. The State's load reduction goal can be translated to emission reduction goals based on the 2002 mercury emissions inventory (Table 6-4). Because tracking in-state reductions will be based on 2002 estimated emissions, the reduction goal for Illinois is 89.29 percent of the 2002 mercury emissions, which is 587 kg/yr (1,291 lbs/yr; Table 6-4).

**Table 6-4. Summary of Baseline and Target Mercury Emissions from Illinois In-State Anthropogenic Sources**

Category	Result
2002 Estimated Emissions	5,479 kg/yr
Target Reduction Rate in Illinois' Anthropogenic Emissions	89.29%
Target Emissions [2002 emissions * (1- 0.8929 reduction)]	587 kg/yr

## 6.5 Margin of Safety

The MOS is a required part of the TMDL to account for technical uncertainties, such as model predictions, analysis of technical data, and the relationship between pollutant loading and receiving water quality. When calculating the TMDL, the MOS can be either explicit (e.g., stated as an additional percentage load reduction), implicit (e.g., conservative assumptions in the TMDL calculations or overall approach), or a combination of the two. For this mercury TMDL, the MOS is implicit through the conservative nature of the modeling approach being applied, which does not consider legacy effects. Although the most recent available largemouth bass data were selected for use in this TMDL, the fish tissue data likely reflect historically higher mercury loads to some extent, because the average life span of largemouth bass is 16 years (TWPD, 2015).

## 6.6 Critical Conditions and Seasonal Variation

TMDLs are required to consider seasonal variations and critical environmental conditions [40 CFR§130.7(c)(1)]. Mercury concentrations in the atmosphere and water column can fluctuate seasonally; however, due to the extremely slow response time of water and fish concentrations to changes in atmospheric loads, essentially no variation in fish mercury concentrations occurs as a result of seasonal variations in atmospheric concentrations. The mercury concentration in the fish represents an integration of all temporal variation up to the time of sample collection. Variability in fish tissue mercury concentrations are more likely influenced by differences in size, diet, habitat, and other undefined factors that are expected to be greater in sum than seasonal variability (MPCA, 2007).

There are critical conditions in the sense that certain water bodies and fish species are more likely to bioaccumulate mercury because of individual water chemistry characteristics and the biochemistry of individual fish species. This aspect of critical conditions has been addressed in this TMDL by using a top predator fish species known to have high bioaccumulation potential. Thus, the critical conditions are assumed to be adequately addressed in the existing analysis.

## 6.7 TMDL Summary

The components of the mercury TMDL are summarized in Table 6-5.

**Table 6-5. Summary of TMDL Components**

<b>TMDL Components</b>	<b>Result</b>
<b>Target Level and Reduction Factor</b>	
Target Fish Mercury Concentration (Fish Tissue Residue Value)	0.06 mg/kg
Baseline Mercury Concentration for Largemouth Bass	0.28 mg/kg
Reduction Factor	78.57%
<b>Mercury Load for Baseline Year 2001</b>	
Point Source Load	No detectable concentration
Nonpoint Source Load	33.51 kg/year
Total Baseline Load	33.51 kg/year
<b>Final TMDL</b>	
Loading Capacity (LC)	0.020 kg/day
Margin of Safety (MOS)	Implicit
Wasteload Allocation (WLA)	0.0003 kg/day
Load Allocation (LA)	0.020 kg/day
<b>Mercury Load Allocation for In-State and Out-of-State Deposition Sources</b>	
In-State Contribution to LA <sup>a</sup>	0.0036 kg/day
Out-of-State Contribution to LA <sup>b</sup>	0.0160 kg/day
<b>Necessary Reduction from Anthropogenic Emission Sources</b>	<b>89.29%</b>

Note: numbers may not sum exactly due to rounding

<sup>a</sup> Anthropogenic sources only

<sup>b</sup> Anthropogenic and natural sources

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# 7

## Implementation Plan and Monitoring Recommendations

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To achieve the mercury load allocations described in Section 6, mercury loads must be significantly reduced. Atmospheric deposition of mercury is the most significant source of mercury to the study area waterbodies (either through direct deposition to the study area or indirectly through transport from portions of Lake Michigan outside the study area), with point and nonpoint sources contributing a much smaller proportion. The Water Division, which includes the TMDL program, has no direct regulatory control over sources of mercury to the atmosphere. TMDLs that call for reduction in sources for which a NPDES permit is not required should provide a reasonable assurance that the controls will be implemented and maintained. It is important to reduce all possible sources of mercury, as mercury cycles from atmosphere to surface water. Atmospheric mercury that is intercepted by impervious area can be removed before it continues to cycle through the system by adjusting existing controls that remove other stormwater pollutants. Monitoring can identify areas likely to contain sinks of mercury. Focusing on a preventative, best management approach can provide a reasonable assurance that the controls needed to reduce mercury and other pollutants will be implemented and maintained.

Over the last several decades, atmospheric mercury emissions in the Great Lakes region have declined substantially (Section 2.1.1). Most of the decline can be attributed to decreases in mercury emissions from medical and municipal waste incinerators. The implementation actions discussed in this section may accelerate this rate of decline by actively reducing sources of mercury that have been previously volatilizing and contributing to elevated atmospheric mercury concentrations.

This section identifies potential sources to target for mercury control and describes a suite of appropriate Best Management Practices (BMPs) for reducing mercury loads including existing activities to reduce mercury, funding opportunities, reasonable assurances for making progress toward achieving the TMDL target, and monitoring. IEPA will work with these sources to identify an appropriate combination of BMPs for both NPDES permitted and unpermitted sources to implement needed reductions and ensure that the NPDES permits in the study area are consistent with the TMDL goals.

### 7.1 Identifying Potential Sources to Target for Control

Atmospheric mercury loads can be reduced through the targeted reduction of mercury sources in Illinois. The identification of all mercury sources is a difficult, but important, step.

#### 7.1.1 Identification of Potential Mercury-Containing Products

Sznopek and Goonan (2000) compiled information regarding the past uses of mercury, which can be helpful in identifying controllable sources of mercury to the atmosphere. The most common uses until 1992 were the chlor-alkali process and batteries (Figure 7-1). Mercury use in both batteries and paint was banned in the 1990s, leading to an overall significant drop in mercury use (Sznopek and Goonan 2000). Other major sources of mercury are switches (in thermostats and automobiles), lightbulbs, and dental and laboratory instruments. Reductions in all of these uses have been implemented over time through various

state and Federal regulations, but mercury use is still allowed in some applications. As mentioned in Section 4, mercury from these sources can be released into the atmosphere or transported in stormwater runoff. Thus, identifying and cleaning up existing sources is important to prevent future discharge.

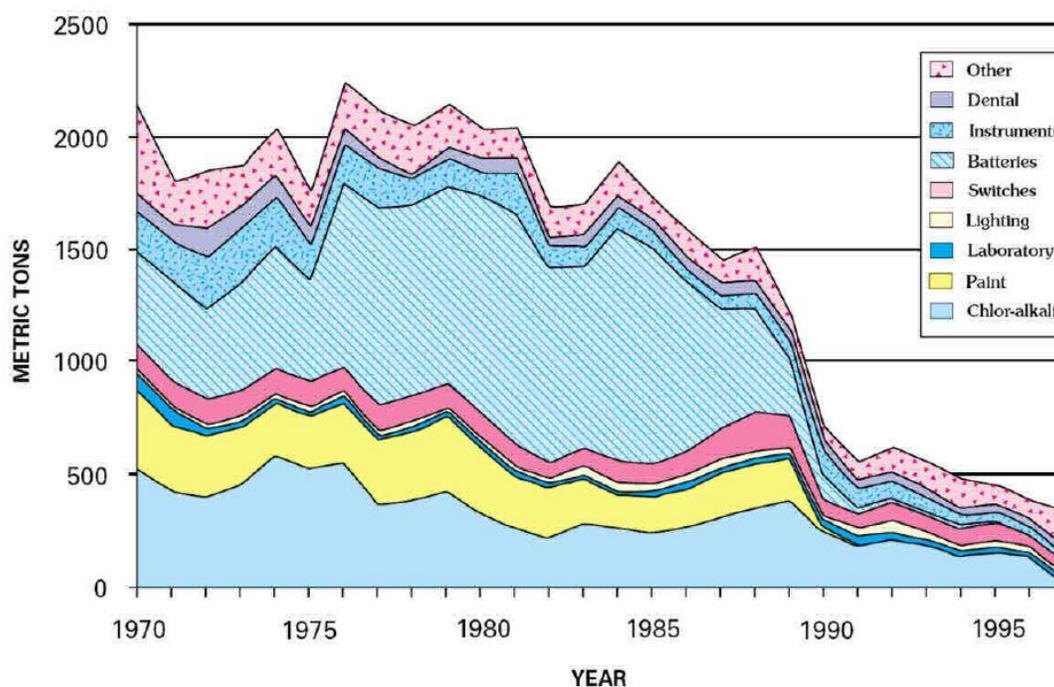


Figure 7-1. U.S. Industrial Consumption of Mercury, 1970-1997. (Source: Sznopce and Goonan, 2000)

### 7.1.2 Point Sources

NPDES-permitted point sources, including MS4 stormwater runoff, are not estimated to be a significant source of mercury. In order to ensure that future MS4 loads meet the TMDL, the MS4 WLA will be addressed in permits issued by IEPA requiring the implementation of BMPs.

## 7.2 Mercury BMPs

This section summarizes BMPs to reduce mercury loads and describes their appropriateness. Although the largest source of mercury is coal-fired electric utilities (discussed in Section 4.2.2), air sources cannot be controlled through a TMDL. However, air programs at the state and Federal level are working to reduce mercury emissions. They are summarized in Section 7.4 of this report.

The BMPs described in this section are expected to reduce mercury from both nonpoint and point (i.e., MS4) sources, including atmospheric mercury that is deposited onto surface water or soil and can be transported into Lake Michigan. Most of the BMPs discussed below can be implemented as part of local stormwater management plans or in MS4 permits. Table 7-1 provides information on the implementation points, sources, and pathways that are addressed for the range of BMPs. Table 7-2 summarizes the level of effectiveness that can be achieved in reducing contaminant loads to the storm sewer system for the range of BMPs described below.

### 7.2.1 Institutional BMPs

Institutional BMPs are focused on information sharing and governmental practices to help businesses and the general public avoid, or clean up and properly dispose of, products containing mercury. These BMPs require the least amount of infrastructure, engineering work, maintenance, and disturbance of existing land, because their purpose is to avoid the continued use or volatilization of mercury. The institutional BMPs listed below will help reduce mercury loads to the atmosphere through cleaning up existing sources and properly disposing of mercury-containing products and waste.

- Conduct public education and outreach campaigns to spread information about the potential sources of mercury, what to do with them if discovered, and safer alternatives. Information should be shared with buyers and suppliers of industrial equipment, consumers, and residents who fish for recreation or subsistence, to increase their awareness of fish advisories and the fish species that contain the highest concentrations of mercury.
- Promote wider/higher rate of recycling mercury-containing products to reduce the risk of mercury discharging from fluorescent light bulbs, thermometers, switches, instruments, etc. into Lake Michigan (can apply to homeowners and businesses).
- Help operators safely use drum top crushers according to regulation for volume reduction of spent fluorescent lamps.
- Innovatively reduce mercury use in hospitals.
- Continue to implement existing take-back programs (government- or non-profit-run programs to accept mercury-containing waste). The results of the statewide Mercury Product Stewardship Program for 2011-2013 are summarized in Table 7-3. Legislation banning the sale/use of a large variety of mercury-containing products has been passed in Illinois (Section 7.4.3).
- Conduct targeted street sweeping: modify street sweeping frequency and the areas covered to target sources of mercury or, when more material is washing down streets, to prevent it from entering storm drains.
- Clean up illegally dumped waste.
- Review local/regional laws regulating waste disposal, and revise as necessary. This could include implementing fines for improperly disposing of mercury and sharing information on safer alternatives for lighting, instruments, switches, etc.
- Create a mercury dental amalgam management BMP brochure,
- Develop a fact sheet to show Illinois consumers what products contain mercury, what should be recycled, and where.

	Vehicle Recyclers, Crushers, and Scrap Metal Recyclers Participating	Mercury Switches Removed	Collection Locations Participating	Mercury-switch Thermostats Collected
2011	157	45,251	42	7,229 <sup>1</sup>
2012	153	40,693	104	13,061 <sup>2</sup>
2013	185	39,103	135	12,479 <sup>3</sup>

<sup>1</sup>An additional 910 loose mercury switches or "bulbs" were collected in 2011.

<sup>2</sup>An additional 2,452 loose mercury switches or "bulbs" were collected in 2012.

<sup>3</sup>An additional 757 loose mercury switches or "bulbs" were collected in 2013.

**Figure 7-2. Outcomes of Mercury Product Stewardship Program, 2011-2013 (Source: IEPA 2015a)**

### 7.2.2 Contaminated Sites and Soil Remediation BMPs

These BMPs involve identifying and cleaning up soil that has been contaminated from past or continuing use of mercury. It is important to identify and remediate contaminated soil before it can be mobilized and transported into the storm drain system, especially during wet weather, to avoid further discharge and distribution into Lake Michigan and tributaries. In addition, remediation of mercury-contaminated soil and sites will also prevent further release to the atmosphere. Significantly more equipment use and land disturbance are required for these solutions than the institutional controls addressed previously. Examples of contaminated site and soil remediation BMPs include:

- Identification and elimination of storage or use of mercury: removal of old equipment containing mercury and proper disposal of it, in addition to soil remediation if mercury was spilled.
- Building remodeling or demolition: identification of older buildings that may contain mercury and replacement of fixtures with safer alternatives, or remove the buildings altogether. Common options include identifying and disposing of fluorescent lights, thermostats, surfaces painted with mercury-containing paint, etc.

### 7.2.3 Treatment Control BMPs (MS4 Stormwater BMPs)

These BMPs are engineered options to be installed or built within the existing storm sewer infrastructure to capture sediment containing mercury and prevent it from being discharged to Lake Michigan. These BMPs can be implemented anywhere, but the limiting factor is access, since they require regular inspection and maintenance and specialized knowledge for installation. Due to the increased expense of this class of BMPs compared with institutional BMPs, it may be more cost effective to first conduct an illicit discharge investigation to determine if and where a mercury source is located within the stormwater system (see Section 7.5.4 for a description of such an investigation). With that information, implementing treatment BMPs will be targeted and much more effective. These BMPs are effective at treating a range of contaminants and are not limited to controlling mercury loads. They are organized by the placement of the engineering practice relative to storm sewer pipes. More information on these BMPs can be found through the California Stormwater Quality Association (CASQA), 2003. These BMPs can be applied at three different locations within the stormwater system:

- Pipe entrance
  - Capture of mercury before it enters stormwater pipes

- Includes infiltration trenches, basins, retention and reuse (rain barrels or underground tanks), ponds, detention basins, swales, buffer strips, bioretention
- Installed within MS4 pipes
  - Includes filters, screens, wet vault<sup>8</sup>, hydrodynamic separators
  - Usually have high maintenance requirements and can sometimes back up flow when not maintained properly
- End of pipe
  - Includes sedimentation basins and constructed wetlands

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<sup>8</sup> A wet vault is a BMP that consists of a permanent pool of water in a vault that rises and falls with storms and has a constricted opening to let runoff out. Its main treatment mechanism is settling of solids that are contaminated.

**Table 7-1. BMP Application for Controlling Mercury in Urban Areas Relative to Sources (Source: San Francisco Estuary Institute 2010)**

Best Management Practice (BMP) Category	Implementation Points								Applicable sources and pathways	
	Dispersed				On the street	Start of pipe	Within pipe	End of pipe	Hg	
	Private homes	Public lots, schools, hospitals, govt bldgs and research institutions	Private offices and businesses	Other private lots and industrial yards					Sources	Pathways
<b>Institutional BMPs</b>										
Education and outreach	√	√	√	√					IUP,ID,HW,BDR	
Volunteer cleanup efforts	√	√	√	√	√				IUP,ID,HW,BDR	
Recycling	√	√	√	√					IUP,ID,HW,BDR	
Amnesties	√	√	√	√					IUP,ID,HW,BDR	
Product Bans/product replacement	√	√	√	√					IUP,ID,HW,BDR	
Enforcement			√	√					OI,IUP,ID,HW,BDR	
Sweeping		√	√	√	√				A,OI,RF,RD,BDR	RI,VT,FT,W
Washing (streets/footpaths)		√	√	√	√				RD,BDR	RI,VT,FT,W
Illicit waste dumping cleanup					√	√	√	√	OI	RI
Stormwater conveyance maintenance				√		√	√	√	A,ID,RF	RI,VT,FT,W
<b>Treatment BMPs</b>										
Infiltration trench		√	√	√		√			A,OL,RF	RI,VT,FT,W
Infiltration basin		√	√	√		√			A,OL,RF	RI,VT,FT,W
Retention and reuse/irrigation	√	√	√			√		√	A,OL,RF	RI,VT,FT,W
Wet Pond		√	√	√		√			A,OL,RF	RI,VT,FT,W
Constructed wetland		√	√	√		√		√	A,OL,RF	RI,VT,FT,W
Extended detention basin		√	√	√		√		√	A,OL,RF	RI,VT,FT,W
Vegetated swale		√	√	√		√			A,OL,RF	RI,VT,FT,W
Vegetated buffer strip		√	√	√		√			A,OL,RF	RI,VT,FT,W
Bioretention (rain garden/green roof)	√	√	√	√		√			A,OL,RF	RI,VT,FT,W
Media filter		√	√	√				√	A,OL,RF	RI,VT,FT,W
Water quality inlet		√	√	√				√	A,OL,RF	RI,VT,FT,W
Wet vault		√	√	√				√	A,OL,RF	RI,VT,FT,W
Hydrodynamic separation		√	√	√				√	A,OL,RF	RI,VT,FT,W
Drain insert		√	√	√				√	A,OL,RF	RI,VT,FT,W
Flow diversion to wastewater treatment								√	All sources	All pathways

True sources: deposition= A

Source areas: Old industrial - OI, Hg products still in use = IUP, Illegal disposal - ID, Recycling facilities = RF, Road deposits = RD, Home and work place = HW

Building demolition and remodeling = BDR

Transport pathways: Runoff from impervious surfaces = RI, Vehicle tracking = VT, Foot tracking = FT, Wind = W

**Table 7-2. Program Assessment Effectiveness for BMPs (Source: San Francisco Estuary Institute 2010)**

Best management practice (BMP) category	Most applicable effectiveness assessment outcome levels					
	Level 1 Documenting activities	Level 2 Raising awareness	Level 3 Changing behavior	Level 4 Reducing loads from sources	Level 5 Improving runoff quality	Level 6 Protecting receiving water quality
<b>Institutional BMPs</b>						
Education and outreach	√	√	√			
Volunteer cleanup efforts	√					
Recycling	√			√		
Amnesties	√			√		
<b>Product Bans / product replacement</b>	√			√		
Enforcement	√	√	√	√		
Sweeping	√			√		
Washing (streets/footpaths)	√			√		
Illicit waste dumping cleanup	√			√		
Stormwater conveyance maintenance	√			√	√	
<b>Treatment BMPs</b>						
Infiltration trench	√			√	√	
Infiltration basin	√			√	√	
Retention and reuse / irrigation	√			√	√	
Wet Pond	√			√		
Constructed wetland	√			√		
Extended detention basin	√			√		
Vegetated swale	√			√	√	
Vegetated buffer strip	√			√	√	
Bioretention (Rain garden / green roof)	√			√	√	
Media filter	√			√		
Water quality inlet	√			√		
Wet vault	√			√		
Hydrodynamic separation	√			√		
Drain insert	√			√		
Flow diversion to wastewater treatment	√			√	√	√

## 7.3 Funding Opportunities

The most likely funding sources to implement the BMPs described in the previous section are the Great Lakes Restoration Initiative, GLRI (<http://greatlakesrestoration.us/index.html>), the Illinois Green Infrastructure Program for Stormwater Management ([www.epa.state.il.us/water/financial-assistance/igig.html](http://www.epa.state.il.us/water/financial-assistance/igig.html)), and Nonpoint Source Section 319 grants (<http://www.epa.state.il.us/water/financial-assistance/nonpoint.html>). However, multiple other programs can aid in funding measures to reduce mercury, as shown in Table 7-3.

**Table 7-3. Funding Opportunities for Implementation of BMPs and Other Measures for Reducing Mercury**

Funding Opportunity	Description
<b>United States Environmental Protection Agency</b>	
Great Lakes Restoration Initiative	Funds various projects, including a program area focused on Areas of Concern like Waukegan Harbor.
<b>National Oceanic and Atmospheric Administration</b>	
Coastal Zone Management Program	Assists states in implementing Coastal Zone Management programs approved by NOAA.
Coastal Services Center Cooperative Agreements	Provide technical assistance and project grants through a range of programs and partnering agreements, all focused on protecting and improving coastal environments.
<b>Illinois Environmental Protection Agency</b>	
Illinois Green Infrastructure Program for Stormwater Management	Grants are available to local units of government and other organizations to implement green infrastructure BMPs to control stormwater runoff for water quality protection in Illinois. Projects must be located within an MS4 or CSO area. Funds are limited to implementation.
Nonpoint Source Section 319 Grants	Grants are available to local units of government and other organizations to protect water quality in Illinois. Projects must address issues relating to nonpoint source pollution (like stormwater runoff). Funds can be used to implement watershed management plans, including the development of information/education programs for the installation of BMPs.
Priority Lake and Watershed Implementation Program	Funds implementation of protection/restoration practices that improve water quality, mostly on small, publicly accessible lakes.

## 7.4 Reasonable Assurance

This TMDL is based upon the assumption that in-state and out-of-state nonpoint source loads of mercury to the nearshore area of Lake Michigan will be reduced in the future. TMDLs that allow for reduction in sources for which an NPDES permit is not required should provide a reasonable assurance that the controls will be implemented and maintained. As discussed in the report, global anthropogenic emissions of mercury are the source of the vast majority of mercury deposition in the watershed, and IEPA's achievement of the TMDL goal is dependent upon regional and global mercury emission reductions.

### 7.4.1 Water Programs-State

The point sources in this report only contribute a small portion of Illinois's mercury loading when compared with nonpoint sources or atmospheric deposition. However, NPDES permit holders will be required through their permit to determine if their facility adds to the mercury load or if the presence of

mercury is due solely to facility pass-through or because of storm water conveyance. Facilities that do add to the mercury load will receive an effluent limit and will be required to meet the limit or develop and implement a cost-effective mercury waste minimization plan if one is not already in place to ensure mercury discharges from point sources does not exceed the WLA.

#### **7.4.2 Waste Programs – Federal**

Many efforts have been established to ensure that the quality of the Great Lakes is restored and maintained. In May 2004, a Presidential Executive Order was signed recognizing the Great Lakes as a national treasure and calling for the creation of a "Regional Collaboration of National Significance" and a cabinet-level Federal Great Lakes Interagency Task Force.

The U.S.-Canadian Great Lakes Binational Toxics Strategy marked its 10th anniversary with an annual report which identified that 12 of the 17 goals for source and emissions reductions set in 1997 have been met, and the rest are well advanced.

These programs, along with a host of others that can be found at <http://www.epa.gov/greatlakes/index.html>, ensure that the U.S. Federal Government, the governments of the individual states adjacent to the Great Lakes, and the government of Canada all are taking a variety of steps to address pollution in the Great Lakes system, including reducing sources of mercury.

A number of programs designed to reduce mercury loads to Lake Michigan are already in place. One example is the Great Lake Lakewide Management Plans (LaMPs). The Lake Michigan LaMP was written in 2000 to coordinate all the agencies working on protecting and restoring the lake. The plan tracks efforts like TMDLs and Area of Concern (AOC) clean-ups, as well as overall ecosystem improvement projects that will contribute to mercury reductions in Lake Michigan.

#### **7.4.3 Waste Programs – State**

Another example of waste-related efforts is state legislation enacted to ban particular mercury-containing goods. Several examples of Illinois state law and the date specific requirements became effective are included below:

- 2004: Thermometers (except those in health care facilities) and novelty products (Illinois Public Act 093-0165)
- 2005: All mercury-containing products for K-12 school purchasing (Illinois Public Act 093-0964)
- 2007: Electrical switches and relays (Illinois Public Act 093-0964)
- 2008-2012: Scientific instruments containing mercury (e.g., barometers, pressure transducers, pyrometers); cosmetics containing mercury (Mercury-added Product Prohibition Act 410 ILCS 46)
- 2008: Requires removal of automobile switches before the vehicles are crushed or otherwise processed (Illinois Public Act 094-0732). A non-profit organization, End-of-Life Vehicle Solutions (ELVS), helps facilities remove and collect mercury switches for recycling. This program includes the following:
  - Provides information on makes/models that contain mercury switches, the locations of the switches and how to remove them;
  - Supplies containers to store the removed mercury switches and pays for the cost of transporting the switches to a waste or recycling facility,
  - Pays a \$2 bounty for each mercury switch processed and \$6 for each anti-lock brake g-force sensor recycled to help offset removal costs.
- 2008: Sale and installation of mercury climate control thermostats (Public Act 95-452)
- 2009: Sale and distribution of cosmetics, toiletries, or fragrances containing mercury (Illinois Public Act 95-1019)

- 2011: Requires manufacturers to supply collection points for recycling mercury-containing thermostats (Illinois Public Act 096-1295). The goal is to collect 40,000 thermostats by 2020.
- 2012: Mercury wheel weights and balancers (Environmental Protection Act 415 ILCS 5/22.23c); Added zinc air button cell batteries to list of items banned from sale and distribution in the Mercury-added Product Prohibition Act (Illinois Public Act 97-1107)
- 2016: Requires all mercury thermostats to be removed from any commercial building prior to demolition. Also requires that the individual removing the thermostats to arrange in advance to have them delivered to an authorized mercury thermostat collection site. (Illinois Public Act 99-122/Senate Bill 679)

#### 7.4.4 Air Programs – Federal

The Federal Clean Air Act (CAA), section 112, requires the USEPA to regulate emissions of toxic air pollutants, including mercury, from a published list of industrial sources referred to as "source categories." As required under the CAA, the USEPA developed a list of source categories that must meet control technology requirements for these toxic air pollutants. These sources are predominantly related to fuel combustion (e.g., utilities, industrial boilers). In 2012, EPA proposed the Mercury and Air Toxics Standards (MATS) to require power plants to reduce their emissions of mercury and other toxic air pollutants further.

#### 7.4.5 Air Programs – State

In 2006, Illinois proposed new regulations that go above and beyond the Federal Clean Air Mercury Rule regulations (the predecessor to MATS, passed in 2004) to curb mercury emissions from coal-fired electrical generating units. The rule is divided into two phases. As of July 1, 2009, coal-fired power plants must meet either a 0.0080 lbs mercury/GWh emission standard or capture 90 percent of inlet mercury. Owners of multiple plants can average the limit across their fleet to meet the standard. Phase II, which began on January 1, 2013, applied on a single-plant basis, rather than being system-wide for those operating more than one plant. No banking or trading is allowed under this rule, unlike the Federal rule. It was expected to result in 488 fewer pounds of mercury emissions per year (starting in 2009), compared to the Federal rule (IEPA, 2006).

#### 7.4.6 Support for Regional, National and International Mercury-reduction Policies and Initiatives

Because the TMDL identifies that over 90% of the mercury comes from sources outside of the state, it is recommended that IEPA follow the model of Minnesota from their statewide mercury TMDL implementation plan (MPCA, 2009) and work with neighboring states', environmental groups, EPA, industries, the private/public sector, other interested parties and the general public as appropriate to establish policies and initiatives to achieve emission reductions from sources in the U.S. and other countries to meet Illinois' Mercury TMDL targets for deposition. The objectives of this work shall be to establish policies and programs that result in significant emission reductions and consistency of policies among states and countries.

These objectives can be achieved through technology and program transfer, after identifying model efforts globally. Initiatives with these objectives should be considered for support and involvement:

- Reduce or eliminate releases of mercury through pollution control or the use of alternative products and processes.
- Reduce or eliminate the intentional use of mercury in products and processes. This could include bans on the manufacture or sale of products with mercury.

- Maximize the proper end of life management of mercury products currently in use through outreach, readily accessible collection infrastructure and regulation.
- Eliminate the sale and export of mercury recovered from products and processes for uses that have a high likelihood of resulting in an environmental release.

## 7.5 Monitoring Recommendations to Track TMDL Effectiveness

Post-TMDL monitoring consists of collecting and analyzing data to evaluate progress towards attaining the TMDL target. Post-TMDL monitoring can assist in determining whether planned control actions are sufficient, or whether further measures need to be implemented. This section describes existing and recommended mercury monitoring for tracking trends and assessing TMDL effectiveness.

### 7.5.1 Fish Tissue Monitoring

IEPA monitoring is described in IEPA, 2014a. Within the Great Lakes Basin, Illinois monitors fish tissue mercury on an annual basis as part of its FCMP. Results are used to assess the status of existing fish consumption advisories or issue new advisories. Continued monitoring provides important information for the public from a health perspective. Fish tissue mercury concentrations from the FCMP can be used to assess progress towards the TMDL target. These data should be compiled as they become available and assessed to determine if mercury concentrations are decreasing.

The Illinois Water Quality Monitoring Program will conduct special samples monitoring as needed by special circumstances (e.g., investigations of spills, fish kills, and toxic chemical cleanup stations). The FCMP can also request specific numbers and sizes of selected fish or other aquatic species to be collected by field sampling teams or other personnel. Such samples may be designated as high priority for analysis by IEPA or another designated laboratory. Costs for collection and analysis of such samples shall be paid, to the extent possible, by the party or parties responsible for the special circumstance.

### 7.5.2 Atmospheric Mercury Monitoring

Total mercury in precipitation has been monitored weekly through the Mercury Deposition Network since 1996. The closest site to the study area watershed is at the Indiana Dunes National Lakeshore. Additional monitoring data for Lake Michigan atmospheric mercury deposition may also be available through the Canadian Atmospheric Mercury Measurement Network. Data collected through these programs should be compiled and analyzed to assess changes in mercury concentrations over time.

### 7.5.3 Air Emissions of Mercury

Air emissions of mercury from Illinois sources can be tracked over time using the National Emissions Inventory (NEI). The NEI, available by state, is a comprehensive and detailed estimate of air emissions of both Criteria and Hazardous air pollutants from all air emissions sources. The NEI is prepared every three years by the USEPA, based primarily on emission estimates and emission model inputs provided by state, local, and Tribal air agencies for sources in their jurisdictions, and is supplemented by data developed by the USEPA.

### 7.5.4 Illicit Discharge Survey

An illicit discharge survey should be conducted on storm sewers and surface waters discharging to Lake Michigan if it is suspected that there have been illicit discharges of mercury. Priority should be given to those discharges occurring within 500 meters of the beach or within the lake shoreline beach area. This survey is typically conducted by municipal public works personnel or a consultant. The survey involves a

systematic screening of stormwater outfalls to determine the presence of an illicit discharge and is required by Illinois' Stormwater NPDES General Permit for Discharges from Small MS4s. The screening includes a physical inspection of the outfall, surrounding area and discharge, and sampling of the discharge for pollution indicators. Following the outfall survey, follow-up investigations are conducted in the stormwater conveyance system to narrow down and locate the source of the illicit discharge.

Suggested follow-up investigations/solutions:

- Conduct illicit discharge investigations for mercury sources in nearby storm sewers.
- Street Sweeping will reduce the amount of toxic pollutants that end up in the lakes/streams
- Separate Stormwater Collection System – use Jet-Vacuum for regular cleaning
- Mitigate stormwater flow from direct drainage areas by using green infrastructure (GI) measures such as retention basin, green roofs, bioswales or permeable pavements to eliminate ponding and drainage to the beach.

## 7.6 Schedule

A detailed schedule for implementation of the suggested BMPs is not appropriate in this document. Practical and financial limitations potentially need to be considered and overcome and communities must be engaged in order to implement the BMPs in this section of the TMDL. However, IEPA intends to engage the public starting with a working meeting to engage partners including the cities in the study area to prioritize the recommended strategies to determine the most feasible options.

NPDES permits must be consistent with the WLA and the assumptions used to derive them. Existing wastewater treatment plants that discharge to Lake Michigan are expected to meet effluent limits that are outlined in their permits. Current NPDES permits will remain in effect until the permits are reissued, provided IEPA receives the NPDES permit renewal application prior to the expiration date of the existing NPDES permit. The WLAs will be incorporated into the permits upon reissuance.

The MS4 communities are covered under the General NPDES Permit No. ILR40 that expired on March 31, 2014. However, General Permit NPDES No. ILR40 is considered to be “administratively continued” until a new General Permit is reissued. The BMPs contained in this section of the TMDL can be adopted as appropriate, as minimum measures for permits to be consistent with the WLA contained in the TMDL and will be incorporated into the MS4 General Permit by reference. The General Permit will remain in effect until a new General Permit is reissued (pending new Storm Water Regulations).

The current General Permit Part III- Special Condition (C) requires the MS4 Permittee to comply with the WLA when a TMDL is developed for that particular watershed within 18 months of notification by IEPA of the TMDL.

Implementation of the LA is voluntary. However, IEPA believes that the TMDL target will be met based on activities discussed in this section of the TMDL.

# 8

## Public Participation

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[To be filled in following the January 2016 public meetings]

## 9

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## Appendix A:

# 303(d) List of Segments Impaired due to Mercury

**Table A-1. Mercury-impaired segments in the project study area**

TMDL Zone	HUC 10	Waterbody Name	Segment ID	Size	Size Units	Designated Use Impairment
Nearshore open water/shoreline	Lake Michigan Shoreline	North Point Beach	IL_QH-01	0.42	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	IL Beach State Park North	IL_QH-03	2.72	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Waukegan North Beach	IL_QH-04	1.51	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Waukegan South Beach	IL_QH-05	1.55	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	IL Beach State Park South	IL_QH-09	4.67	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Lake Bluff Beach	IL_QI-06	5.5	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Lake Forest Beach	IL_QI-10	3.79	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Rosewood Beach	IL_QJ	2.19	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Park Ave. Beach	IL_QJ-05	4.08	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Glencoe Beach	IL_QK-04	2.15	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Tower Beach	IL_QK-06	1.17	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Lloyd Beach	IL_QK-07	0.32	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Maple Beach	IL_QK-08	0.57	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Elder Beach	IL_QK-09	0.92	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Kenilworth Beach	IL_QL-03	0.76	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Gilson Beach	IL_QL-06	2	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Greenwood Beach	IL_QM-03	0.38	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Lee Beach	IL_QM-04	0.43	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Lighthouse Beach	IL_QM-05	0.64	Miles	Fish consumption

TMDL Zone	HUC 10	Waterbody Name	Segment ID	Size	Size Units	Designated Use Impairment
Nearshore open water/shoreline	Lake Michigan Shoreline	Northwestern University Beach	IL_QM-06	0.73	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Clark Beach	IL_QM-07	0.94	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	South Boulevard Beach	IL_QM-08	0.98	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Touhy (Leone) Beach	IL_QN-01	0.41	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Loyola (Greenleaf) Beach	IL_QN-02	0.29	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Hollywood/Ostermann Beach	IL_QN-03	0.27	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Foster Beach	IL_QN-04	0.65	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Montrose Beach	IL_QN-05	1.45	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Juneway Terrace	IL_QN-06	0.07	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Rogers Beach	IL_QN-07	0.16	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Howard Beach	IL_QN-08	0.16	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Jarvis Beach	IL_QN-09	0.26	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Pratt Beach	IL_QN-10	0.19	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	North Shore/Columbia	IL_QN-11	0.16	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Albion Beach	IL_QN-12	0.53	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Thorndale Beach	IL_QN-13	0.69	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	North Ave. Beach	IL_QO-01	0.55	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Fullerton Beach	IL_QO-02	3.07	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Webster Beach	IL_QO-03	0.29	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Armitage Beach	IL_QO-04	0.27	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Schiller Beach	IL_QO-05	0.57	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Oak St. Beach	IL_QP-02	0.64	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Ohio St. Beach	IL_QP-03	0.93	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	12th St. Beach	IL_QQ-01	1.93	Miles	Fish consumption

TMDL Zone	HUC 10	Waterbody Name	Segment ID	Size	Size Units	Designated Use Impairment
Nearshore open water/shoreline	Lake Michigan Shoreline	31st St. Beach	IL_QQ-02	3.32	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	49th St. Beach	IL_QR-01	1.43	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Jackson Park/63rd Beach	IL_QS-02	0.73	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Rainbow	IL_QS-03	3.34	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	57th St. Beach	IL_QS-04	0.33	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	67th St. Beach	IL_QS-05	0.71	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	South Shore Beach	IL_QS-06	0.43	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Shoreline	Calumet Beach	IL_QT-03	1.29	Miles	Fish consumption
Nearshore open water/shoreline	Lake Michigan Open Water	Open waters Lake Michigan Nearshore	IL_QLM-01	180	Square miles	Fish consumption
North Point Marina Harbor	North Point Marina Harbor	North Point Marina Harbor	IL_QH	0.121	Square miles	Fish consumption
Waukegan Harbor	Waukegan Harbor	Waukegan Harbor North	IL_QZO	0.0652	Square miles	Fish consumption, Aquatic life
Calumet Harbor	Calumet Harbor	Calumet Harbor	IL_3S	2.4	Square miles	Fish consumption
Diversey Harbor	Diversey Harbor	Diversey Harbor	IL_QZI	0.04563	Square miles	Fish consumption

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